

**Fish Lake
Feasibility Study**

March 4, 1992

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CONTENTS

List of Figures and Tables	iii
Foreword	
Auspices	v
Scope and Limitation	v
Acknowledgements	vi
Executive Summary	vii
Introduction	
Description of Fish Lake Watershed	1
Problems in the Fish Lake Watershed	1
Review of Previous Work	3
Overview of This Study	6
Watershed Land Use Practices	
Methods	7
Highly Erodible Land	8
Sediment and Nutrient "Hotspots"	9
Peat Mining	11
Stream Channels	14
Future Plans for Cranberry Bog	14
Peat Mining Regulations	14
Livestock Operations	17
Other Influences	17
Water Quality Survey	
Methods	19
Results and Discussion	21
Sediment Coring and Bathymetric Survey	
Methods	34
Results and Discussion	36

Aquatic Macrophyte Survey	
Methods	43
Species Composition and Areal Coverage	43
Changes Since Previous Work	57
Purple Loosestrife	58
Lake Management and Restoration Alternatives	
Macrophyte Control	59
Nutrient and Sediment Control	60
Lake and Watershed Management Plan	
Watershed Land Treatment	62
Construction of Sediment Traps/Nutrient Filters	63
Aquatic Macrophyte Management	73
Other Watershed Management Considerations	82
Literature Cited	85
Appendix A - Land Treatment Assistance	
Appendix B - Laboratory Reports	
Appendix C - Sediment Deposits	
Appendix D - Local, State and Federal Agencies	

LIST OF FIGURES

Figure 1	Fish Lake Location Map	2
Figure 2	Highly Erodible Land and Conservation Reserve Program	10
Figure 3	Cranberry Bog Sub-Watershed	12
Figure 4	Fish Creek in 1958, 1981 and 1986	15
Figure 5	Legal Drain: Sharp Ditch	18
Figure 6	Water Quality Sampling Points	20
Figure 7	1991 Total Suspended Solids	24
Figure 8	1991 Total Phosphorus	25
Figure 9	1991 5-Day Biological Oxygen Demand	26
Figure 10	1991 Total Kjeldahl Nitrogen	27
Figure 11	1988-91 Total Suspended Solids	30
Figure 12	1988-91 Total Phosphorus	31
Figure 13	1988-91 5-Day Biological Oxygen Demand	32
Figure 14	1988-91 Total Kjeldahl Nitrogen	33
Figure 15	Sediment Core Sample Locations	35
Figure 16	Bathymetric Maps	40
Figure 17	3-Dimensional Map of Lake Bottom	41
Figure 18	3-Dimensional Map of Lake Bottom	42
Figure 19	Upper Lake Vegetation 6/18/91	45
Figure 20	Lower Lake Vegetation 6/18/91	46
Figure 21	Upper Lake Vegetation 8/1/91	50
Figure 22	Lower Lake Vegetation 8/1/91	51
Figure 23	Sediment Basin Locations	65
Figure 24	Typical Sediment Basin	66
Figure 25	Hydraulic Dredge	68
Figure 26	Disposal Site Plan	69
Figure 27	Dredging Sites and Disposal Areas	70
Figure 28	Soils Map of Disposal Areas	71
Figure 29	Upper Lake Macrophyte Control Areas	76
Figure 30	Lower Lake Macrophyte Control Areas	77

LIST OF TABLES

Table 1	1991 Water Quality Sample Results	22
Table 2	Comparison of 1988 and 1991 Water Quality	29
Table 3	Sediment Sampling Results: Fish Creek Delta	37
Table 4	Macrophyte Species and Coverage 6/18/91	47
Table 5	Macrophyte Species and Coverage 8/1/91	52

FOREWORD

Auspices

This portion of the "Fish Lake Feasibility Study" was authorized by the Fish Lake Property Owners Association, Inc., under a grant from the "T by 2000" program of the Indiana Department of Natural Resources, Division of Soil Conservation. J.F. New and Associates received notification of IDNR grant issuance on January 9, 1991. An agreement between the Fish Lake Property Owners Association, Inc. and J.F. New and Associates was formalized on February 4, 1991.

Scope and Limitation

This study proceeds from the recommendations presented in the May, 1990 final feasibility report to the Fish Lake Property Owners Association. The recommendations included a study of macrophyte species composition and extent of growth, mapping of the existing lake bottom and comparison with the 1950's map, and further study of the impacts of peat mining on the water quality of Fish Creek and the lake. The final feasibility report also recommended locating sites for wetland construction near the mouths of both Fish Creek and Mill Creek and implementation of soil conservation measures in conjunction with "T by 2000" and the LaPorte Soil and Water Conservation District. The final report recommended further analysis of the impact of peat mining on lake water quality. Continued selective control of aquatic macrophytes was recommended in certain areas of the lake to facilitate lake use without contributing to water turbidity and algae blooms.

Peat mining was discontinued after the final feasibility report was completed and before this study was authorized. Without data on the Fish Creek streambed and water quality before mining commenced and during mining operations, the effect on the watershed cannot accurately be determined.

Acknowledgements

Water quality analyses were performed by Environmental Testing of LaPorte County, Inc.

The LaPorte Soil and Water Conservation District and the LaPorte County Agricultural Stabilization and Conservation Service allowed use of their aerial photography and provided information on soil conservation programs and funding.

The LaPorte County Health Department provided information on its Fish Lake monitoring program and the LaPorte County Surveyor supplied maps of the legal drains in the county.

Mr. Richard Soper of Pinecrest Industries provided recommendations for aquatic herbicide applications.

We also wish to thank Dan Bryan for the use of his boat for water sampling and macrophyte mapping.

EXECUTIVE SUMMARY

The Fish Lake system in LaPorte County consists of three interconnected basins (Upper Fish Lake, Mud Lake (also known as Sylvan Lake) and Lower Fish Lake) in a 6,300 acre watershed. Previous studies by the Indiana Department of Natural Resources documented excessive macrophyte growth as early as 1969. Macrophyte growth is still a problem despite a continuing control program. Prior studies also described changes in water quality concurrent with an increase of gizzard shad populations.

The prior study completed in May 1990 recommended implementation of structural and cultural watershed improvements to reduce inputs of sediment and nutrients into the lake system. Also recommended were investigation of peat mining impacts, construction of wetlands along Fish Creek and Mill Creek, control of excessive macrophyte growth and control of nutrient recycling from lake bottom sediments.

One major change since the previous study is the cessation of peat mining in Cranberry Bog in 1989 or 1990. The water levels have been allowed to rise as the area is restored to an open-water lake. Sediment and nutrients will no longer be pumped from this basin into Fish Creek. In effect, the entire 980 acre Cranberry Bog sub-watershed has been removed from the Fish Lake watershed.

Nearly eight percent of the Fish Creek watershed is designated Highly Erodible Land (HEL), with about one third of this total enrolled in the Conservation Reserve Program. Most of the HEL fields (7 of 10) drain into isolated potholes and do not affect water quality in Fish Lake. Potential sediment and nutrient "hotspots" in the watershed have been located in the upper reaches of the Fish Creek watershed and on the east side of Mill Creek. Three of these are designated HEL and three have fairly steep grades near waterways.

Water quality was sampled at 11 sites throughout the watershed, including three sites on Fish Creek and three sites on Mill Creek. Results of water quality sampling indicate generally low values for total suspended solids, with higher readings at the mouth of Mill Creek and at the inlet to Mud Lake. Total phosphorus ranged from below detection limits to 0.09 mg/L, with 0.40 mg/L in the upstream Mill Creek sample. Total phosphorus at the mouth of Mill Creek, however, was below detection limits. Five-Day Biological Oxygen Demand for all samples ranged from 0.5 to 4.9 mg/L, with BOD lower for available June samples than April samples. Total Kjeldahl nitrogen varied from 0.8 to 6.7 mg/L, with the highest reading in the upper watershed of Fish Creek. In both the spring and summer samples, Fish Creek showed a reduction in TKN from upstream to

downstream. Levels of TKN in Mill Creek increased slightly in downstream samples. The severe drought in 1991 may have affected sampling results, especially in areas where stream flow was minimal.

Factors possibly contributing to reduced water quality over the past two decades include sediment and nutrient loading from agricultural land and peat mining sites. The older residential developments and septic systems are not major contributors to water quality problems. Previous sediment and nutrient modeling estimated the amount of sediment and nutrients contributed by Fish Creek, a major tributary. The core samples collected as part of this study documented the extent, volume and composition of sediment at the Fish Creek and Mill Creek deltas. Results indicate approximately 120,400 cubic yards of sediment (33,000 cubic yards of de-watered material) in the Fish Creek and Mill Creek deltas.

Aquatic macrophyte species were inventoried and mapped twice during the growing season. Macrophyte coverage in the June survey was most dense in the eastern third of Upper Fish Lake and in the Fish Creek delta. Perhaps because of better water quality in Lower Fish Lake, large floating leaf macrophytes were very limited or absent. The early August survey showed a degeneration of macrophyte beds, a decrease in filamentous algae and increased dominance by chara in Upper Fish Lake. Macrophyte beds in Lower Fish Lake expanded greatly, with continued dominance by submerged species.

Lake management and restoration alternatives include macrophyte control by harvesting, lake drawdown, biological control and chemical control. The latter is recommended as cost effective at \$31,000 per year for extensive treatment. Chemical controls can be selectively applied, for species as well as location.

Nutrient and sediment control alternatives include complete dredging of the Fish Creek and Mill Creek sediment deltas, phosphorus inactivation with alum treatments, wetland development and construction of sediment traps. Sediment traps at Fish Creek and Mill Creek are recommended. This in-lake construction can be completed for about \$65,000 and avoids damaging upstream wetlands.

To a large degree, watershed management is left to individual landowners, although several cost share programs are available. Owners of farm land wishing to preserve soil productivity are urged to contact the LaPorte County Soil and Water Conservation District to determine the most effective treatment for their fields and cropping requirements.

INTRODUCTION

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Description of Fish Lake Watershed

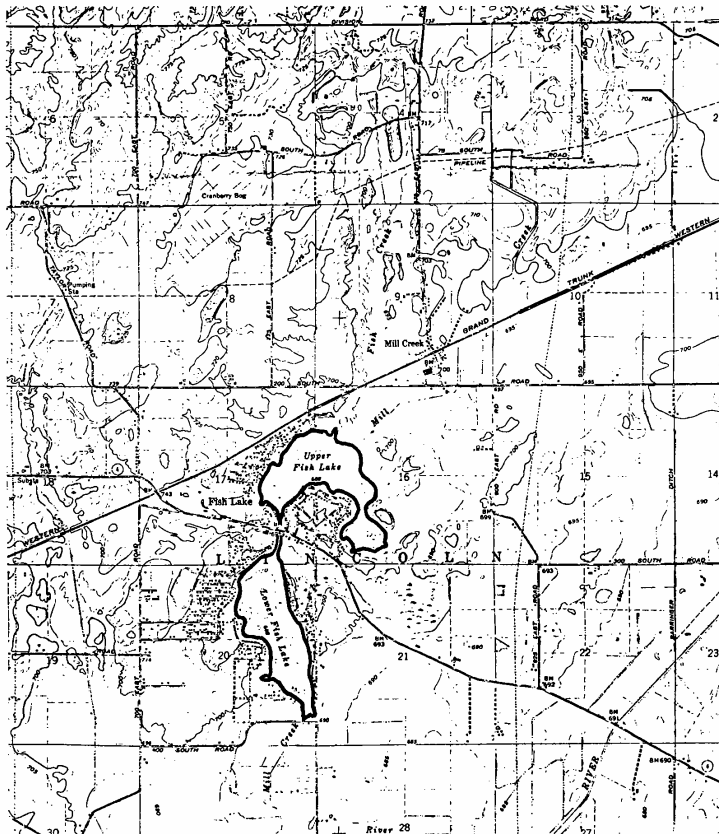
The 6,300 acre Fish Lake watershed lies on the southern edge of the Valparaiso Moraine in LaPorte County and includes three lakes: Upper Fish Lake and a bay known as Mud Lake or Sylvan Lake, totaling 139 acres and Lower Fish Lake, 134 acres (Figure 1). The major tributaries to the lakes are Fish Creek and Mill Creek (Sharp Ditch), which enter at the north end of Upper Fish Lake. The lake area comprises 4.3% of the watershed.

The west and south shorelines of Upper Fish Lake and Mud Lake are almost completely developed with summer homes and permanent residences, but the east shorelines remain undeveloped. All of Lower Fish Lake except the northeast shoreline is developed. The undeveloped areas are characterized by extensive wetlands and unstable, Houghton muck soil.

Problems in the Fish Lake Watershed

The Fish Lake chain has been plagued by several problems. The Fish Creek and Mill Creek inlet areas of Upper Fish Lake have gradually been filled in with sediment high in organic matter content. The recently created shallow water area of Fish Creek has been colonized by purple loosestrife (*Lythrum salicaria*) which has become a major problem along the length of the Fish Creek floodway.

In the lake system, nuisance weed growth and water turbidity have made swimming unpleasant, and fishing and boating difficult. Aquatic weed problems differ through the growing season and effective treatment for large areas is very expensive. Previous lake management was aimed at controlling aquatic vegetation, the visible result of nutrient loading. The effects of weed control have been limited, however without chemical weed control, recreational use of the lake would have been greatly impaired. Although the Fish Lake Property Owners Association has maintained a weed control program, other preventive measures must be taken to improve the water quality in the lake.



LOCATION MAP



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Review of Previous Work

In the "Indiana Lake Classification System and Management Plan" published by IDEM in 1986, the authors discuss several routes leading to eutrophication of lakes. This condition occurs when sedimentation decreases the volume of a lake basin to the point where there is a "substantial increase in inorganic nutrients both from loading from the watershed and regeneration from the sediments." This leads to a gradual eutrophication of the lake, increased sedimentation, and as the basin becomes shallow, an expansion of the littoral (shoreline) macrophyte community. Vegetation changes often follow a pattern starting with macrophytes (visible aquatic vegetation) and associated microflora, progressing to reed swamps characterized by reeds, sedges, flatsedges, bulrushes and cattails. The next step is a gradual change to a marsh with moderate size grasses and the establishment of non-grass species such as shrubs and flowering plants. The final stage is the conversion to terrestrial plant communities. The authors add, "one of the primary concerns in consideration of the effects of cultural eutrophication is the very rapid increase in sedimentation rates which reduce the depth and volume of lakes in relatively short periods of time."

Cultural eutrophication is defined as "the increase of productivity and sedimentation rates as a direct consequence of the activities of man." Symptoms of cultural eutrophication include an "increase in the quantity of the biomass of either the aquatic macrophytes and periphytic algae near the shore or of the algae of the open water regions or both." This symptom has been documented in Indiana Department of Natural Resources fish management studies which indicate that aquatic vegetation coverage of the lake remains about 25% of the surface area, despite a continuing weed control program (IDNR, 1984).

A second indicator of cultural eutrophication is the increase in the percentage composition of gizzard shad in the lake. The IDNR first noted gizzard shad in Fish Lake in 1973 and executed a selective eradication that same year, but by 1984 these plankton feeding fish made up about one-fourth of total fish weight in the lake (IDNR, 1984).

A third sign of eutrophication is a decrease in water transparency and a change in water color. Since 1974 these changes have been documented in IDNR lake management studies of Fish Lake (IDNR 1969 through 1984).

The Indiana Department of Environmental Management (IDEM) has classified Indiana lakes according to trophic status, based on "physical, biological, and chemical measurements made in the deepest basin(s) during summer thermal stratification." Based on its trophic status, Upper Fish Lake is considered a Class Two lake. These are described as "usually productive and very slowly moving toward senescence. They are

impacted by the activities of man, but trophic changes are usually subtle. In the absence of a chemical control program, they frequently support extensive concentrations of macrophytes and/or algae, but seldom to the extent that one or more attainable lake uses are significantly impaired. Class Two includes the majority of Indiana's natural lakes."

The higher water quality of Lower Fish Lake is reflected in its Class One status, defined as those lakes "which often exhibit some oligotrophic or mesotrophic characteristics. These lakes rarely support concentrations of macrophytes or algae that could impair attainable lake uses, and chemical control programs are rarely necessary." Macrophyte mapping as discussed in the next section confirms the limited development of nuisance weeds in Lower Fish Lake.

The Indiana Lake Classification System and Management Plan (IDEM, 1986) further classifies lakes in Lake Management Groups. Upper Fish Lake (including Mud Lake) is in Lake Management Group VII-A, those lakes of "intermediate areas and shallower depths, showing moderate to advanced eutrophication. In general, water quality problems are not severe enough to warrant drastic restoration techniques. In many cases, however, selected restoration procedures, such as macrophyte harvesting, chemical controls, and nutrient deactivation may be applicable. The main management priority, which will improve water quality most effectively on both a short and long term basis, is the limitation of nutrient inputs."

Lower Fish Lake is considered a Class V lake, described as "shallow lakes with high water quality. Management priorities for Group V lakes stress maintenance of present conditions."

The Lake Eutrophication Indices calculated by Harza in 1989 show little change since the initial IDEM study. As might be expected, Upper Fish Lake remains more eutrophic than Lower Fish Lake. A separate Lake Eutrophication Index was calculated for Mud Lake (Harza, 1989). The Indiana Department of Environmental Management reported higher lake eutrophication values in its 1988-1989 report.

	<u>Previous LEI</u>	<u>1988 LEI</u>	<u>1989 IDEM</u>
Mud Lake	--	19	
Upper Fish Lake	22	23	35
Lower Fish Lake	8	7	26

One of the most important standards of water quality is the concentration of phosphorous in the water. In most Indiana lakes, the growth of aquatic vegetation is limited not by a shortage of nitrogen, but by the availability of phosphorous. To this end, the IDEM Lake Eutrophication Index assigns a point value for the levels of this nutrient where higher point values indicate a more eutrophic condition:

<u>Total Phosphorous (parts per million)</u>	<u>Eutrophy Points</u>
At least 0.03	1
0.04 to 0.05	2
0.06 to 0.19	3
0.20 to 0.99	4
1.00 or more	5

The total phosphorous levels measured in previous surveys of Upper and Lower Fish Lake are presented below:

	<u>IDEM mid-1970s</u>	<u>1988 Lake Study</u>	<u>1989 IDEM survey</u>
Mud Lake	----	0.04	----
Upper Fish Lake	0.03	0.04	0.05
Lower Fish Lake	0.02	0.02	0.03

The 15 March 1989 draft report of the feasibility study evaluated lake management alternatives and determined the most effective practices using a three level procedure. The *Initial Identification* resulted in a comprehensive list of reasonable enhancement procedures for controlling aquatic vegetation and reducing phosphorus loading in the lake. The *General Screening* eliminated from further consideration those alternatives not applicable to Fish Lake or which could have unacceptable environmental impacts or which rely on unproven technology. The *Feasibility Evaluation* analyzed the remaining alternatives as to environmental and economic feasibility for enhancing Fish Lake.

The final study recommended mapping the lake bottom for comparison with the 1950's map, a detailed study of the peat mining operation, locating sites for wetland construction near the mouths of the streams, limited macrophyte control in specified treatment areas, and evaluating land treatment practices in the watershed.

Overview of This Study

This study was designed to build upon the previously completed study and provide the Fish Lake Property Owners Association with a scientifically valid lake and watershed management plan. The scope of work for this study includes:

1. Collection of water samples to quantify watershed inputs of sediment and nutrients. The water sampling program was designed to assess the impact of peat mining in the "Cranberry Bog", the Fish Creek sub-watershed and the Mill Creek watershed. Water samples were taken from all influent streams to determine relative contributions of nutrients and sediments from various potential sources within the watershed. Samples of water were analyzed for biological oxygen demand, suspended solids, nitrogen, and phosphorus.
2. Examination of land use practices in order to identify sediment and nutrient "hotspots" in the Fish Lake watershed. The study examined the effectiveness of implementing appropriate land treatment measures in reducing sediment and nutrient transport to Fish Lake. Land use in the watershed was evaluated by field inspections and by examining aerial photography.
3. Limited sediment coring and bathymetric study of Upper Fish Lake to determine the extent of sediment deposition at the mouths of Fish Creek and Mill Creek. The study examined the need for sediment removal, stabilization or other appropriate treatments in these areas. Forty-six core samples were taken from the sediment delta in Upper Fish Lake and evaluated as to sediment type and volume.
4. Survey of aquatic macrophytes in Upper and Lower Fish Lakes to determine species composition and areal coverage. Aquatic vegetation and density over the lakes was recorded and mapped twice during the growing season. The maps and species lists demonstrate the changes in vegetation through the season, and show which areas could be chemically treated and which vegetation should be left intact. Subsequent to the survey, an aquatic plant management plan was developed which includes recommended treatment and non-treatment areas where plants are left intact for habitat and/or filtration.
5. Recommendations for a lake and watershed management plan based on information from previous studies, this study and other information. The plan addresses restoration/management alternatives and recommends the most feasible actions to ensure continued recreational use of the lakes. Preliminary cost estimates are included.

WATERSHED LAND USE PRACTICES

WATERSHED LAND USE PRACTICES

Land use as estimated in the draft feasibility report determined by Turnbell Engineering in the previous feasibility study is summarized as follows:

<u>Land Use</u>	<u>Fish Creek</u>	<u>Mill Creek</u>	<u>Remainder</u>
Watershed size (acres)	2827	1160	2347
Forest	10 %	10 %	2 %
Row crops	54 %	46 %	43 %
Pasture	14 %	10 %	8 %
Urban	0.2 %	4 %	14 %
Wetland	21 %	29 %	21 %

All lakes are affected by land use practices in the watershed, and like most lakes in Indiana, Fish Lake receives detrimental sediment and nutrients. Typical sources include erosion from row crop land, unstabilized stream beds and ditches; fertilizer runoff from crop fields, lakefront lawns and animal waste from feedlots; and other point-sources such as gravel, sand or peat mining operations.

According to the 1989 phosphorus source modeling presented in the 15 March 1989 draft final report, about 78 % of all phosphorus loading to the Fish Lake system is from row crop land, with internal loading from in-lake sediment contributing about 12 % of the total, septic systems about 5 % and all other sources (woodlands, pasture, wetland, urban and precipitation) accounting for less than 5 % of the total. Of the 78 % from row crop land, Fish Creek accounts for 50 %, Mill Creek, 17 %, and the remainder of the watershed for 33 %. In short, the phosphorus source model indicates Fish Creek transports nearly 40 % of the watershed's total annual phosphorus loading.

Methods

Information on designated Highly Erodible Lands (HEL) in the Fish Lake Watershed was obtained from the LaPorte County Soil and Water Conservation District and the LaPorte County office of the Agricultural Stabilization and Conservation Service (ASCS). The map showing fields designated HEL and land enrolled in the Conservation Reserve Program (CRP) was compiled from information obtained from the ASCS.

The LaPorte County soils map and the U.S. Geological Survey 7.5 minute topographic map (Stillwell Quadrangle) provided information on soil types, grades and drainage patterns.

Other land use information was obtained from on-site inspections and conversations with persons knowledgeable of local land use practices.

Highly Erodible Land

Highly erodible soils in agricultural areas of the Fish Lake Watershed are generally not directly adjacent to major drainage ways, but are at the transition zones from upland soils to hydric soils.

Hydric soils such as Adrian, Edwards and Houghton mucks were formed under wetland conditions and are characterized by high organic matter content, high water holding capacity and level surfaces. The Fish Creek floodway is especially well protected by these hydric soil "buffer zones" which, when not drained and farmed, trap sediment and nutrient runoff from adjacent upland soils.

The Food Security Act of 1985 established conservation compliance requirements on Highly Erodible Lands (HEL). Highly Erodible Land is defined by the United States Department of Agriculture as land where "potential maximum erosion is greater than eight times the rate at which the soil can erode and maintain productivity." Highly erodible fields are defined as having one-third or more highly erodible soils, or more than 50 acres of highly erodible soils.

Listed below are the soil types in the Fish Lake watershed defined as Highly Erodible:

ChC	Chelsea fine sand, 6 to 12% slopes
ChD	Chelsea fine sand, 12 to 18% slopes
TcC2	Tracy sandy loam, 6 to 12% slopes, eroded
TcD2	Tracy sandy loam, 12-18% slopes, eroded
TcF	Tracy sandy loam, 25 to 45% slopes

Four hundred ninety-four acres of Highly Erodible Land, about 7.8% of the total watershed, have been identified in the Fish Lake watershed. Of these, 163 acres (about one-third) have been enrolled in the Conservation Reserve Program. An additional 331 acres of non-HEL designated land have been enrolled in the Conservation Reserve Program.

Figure 2 shows the distribution of fields designated Highly Erodible Land and those enrolled in the Conservation Reserve Program.

To remain eligible for USDA program benefits such as wheat and feed grain payments, commodity loans, Conservation Reserve Program annual payments and crop insurance, farm commodity producers were required to develop a soil conservation plan approved by the local Soil and Water Conservation District (SWCD). The plans apply to annually tilled crops on highly erodible fields on which annual crops were grown at least once during the years 1981-1985. Producers were required to begin implementation of the plan by January 1, 1990. Full implementation of the conservation plan is required by January 1, 1995.

Soil and Water Conservation Districts are locally operated subdivisions of state government which work with local groups, county government and state and federal agencies such as the IDNR Division of Soil Conservation's "T by 2000" program, the Purdue University Cooperative Extension Service and the USDA Soil Conservation Service (SCS). The conservation plans developed in cooperation with the Soil and Water Conservation District evaluate crop rotations, tillage practices, cover crops and erosion control structures in reduction of soil loss. Additional information on land treatment assistance is presented in Appendix A.

Sediment and Nutrient "Hotspots"

Potential sediment and nutrient "hotspots" were identified using Soil Conservation Service designations of Highly Erodible Land (HEL), USGS topographic maps and soils maps (Figure 2). All fields designated HEL are in the Fish Creek watershed. Two of the twelve fields designated HEL are enrolled in the 10-year Conservation Reserve Program (CRP) and have been seeded to a permanent cover crop. Of the remaining 10 fields not enrolled in CRP, six drain into isolated potholes of hydric soils and one field is in the Cranberry Bog sub-watershed. Three HEL fields in the Fish Lake watershed are farmed and would benefit from soil conservation and water quality enhancement practices included in the Tri-County Water Quality Project, "T by 2000" and U.S. Department of Agriculture programs. The areas described below have highly erodible soils, are not enrolled in the Conservation Reserve Program, and are located near wetlands or waterways. Two other areas not designated Highly Erodible Land are potential hotspots:

1. A field of Tracy sandy loam (6 to 12% slopes, eroded) in the east half of the northwest quarter of Section 4 is very close to the network of ditches at the north edge of the Fish Creek watershed. If not drained, the Houghton muck at the south edge of this field would afford some natural protection of the watershed.

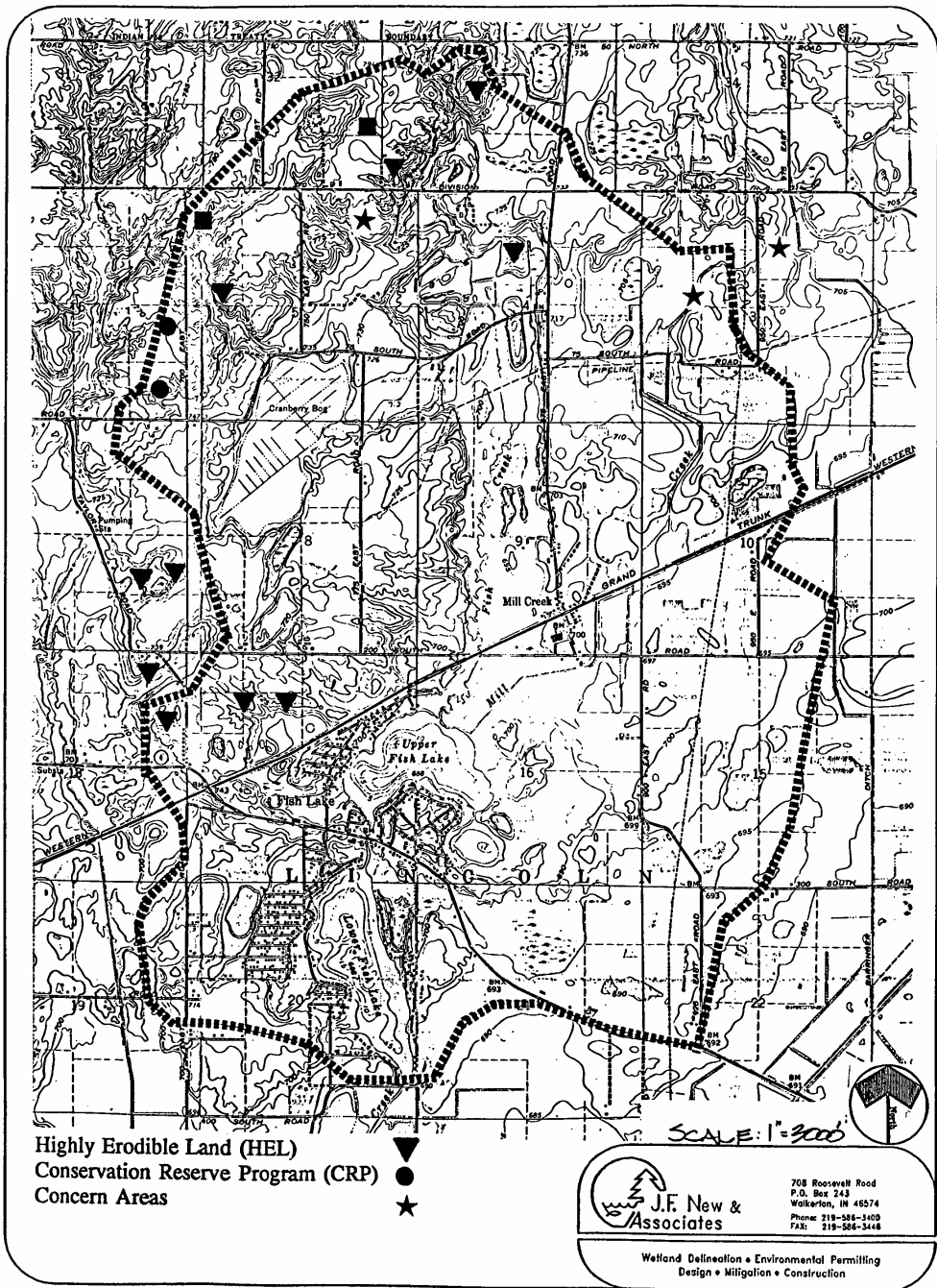


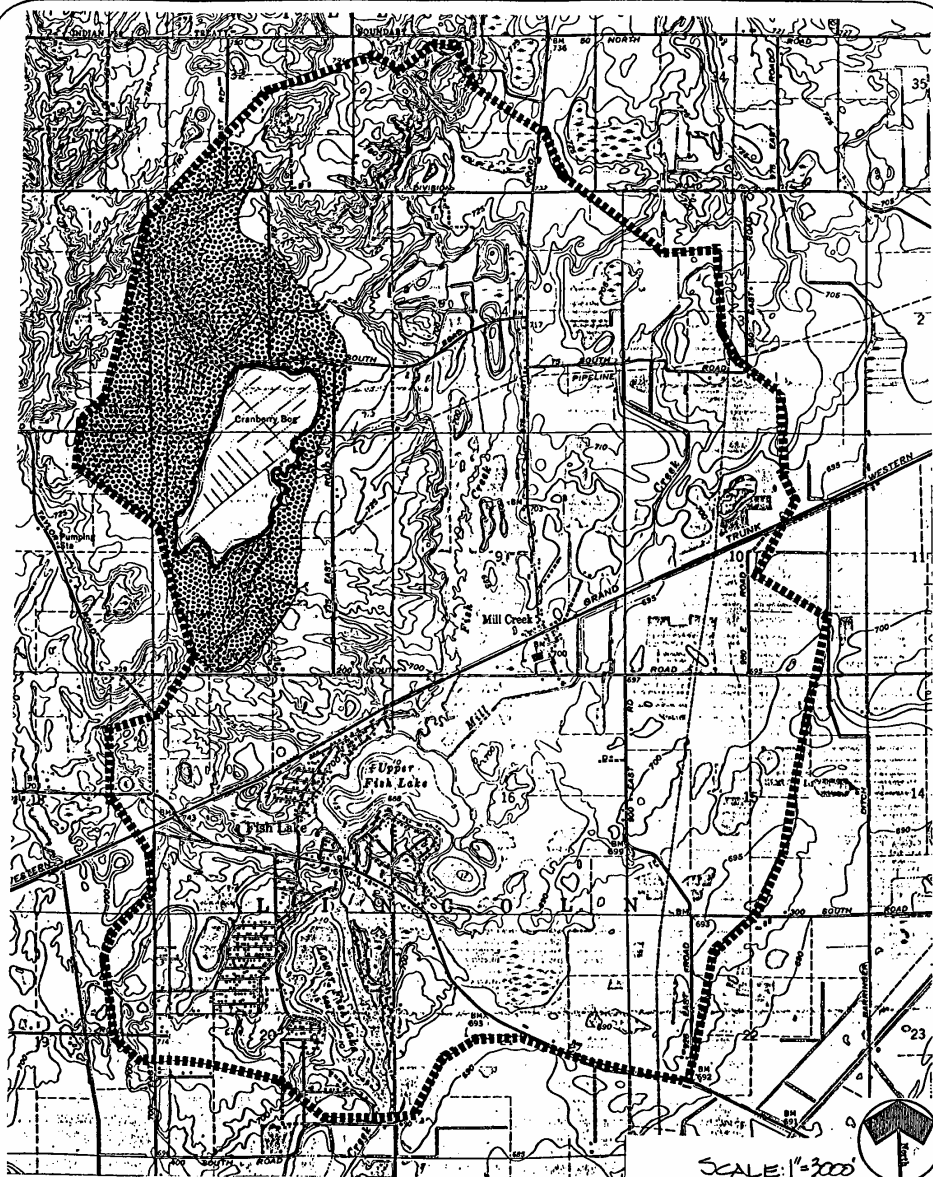
FIGURE 2

2. A large field of Tracy sandy loam (12 to 18% slopes, eroded) in the north half of the southwest quarter of Section 33 drains into a large unfarmed area of Houghton muck at the northernmost edge of the Fish Creek watershed.
3. In the southwest quarter of the southwest quarter of Section 33 is a small HEL field of Tracy sandy loam (6 to 18% slopes, eroded) which drains into Houghton muck adjacent to the upper tributaries of Fish Creek.
4. Although not designated Highly Erodible Land, a large area of Tracy sandy loam (6 to 18% slopes, eroded) in the northeast quarter of Section 5 and the northwest quarter of Section 6 forms a broad swale which drains into a narrow band of Houghton muck on the west side of Fish Creek.
5. A narrow band of Chelsea fine sand (6 to 12% slopes, eroded) about 3/4 mile long lies very near the east bank of Mill Creek. None of these fields is designated HEL, but their proximity to the waterway is cause for concern.

Narrower areas of Tracy sandy loam (6 to 12%, eroded) are located along the major drainageway to the Cranberry Bog in Section 5. One field at the top of this sub-watershed is designated HEL and is enrolled in the Conservation Reserve Program. One 6 acre field is HEL, but not CRP. Future plans for the Cranberry Bog area apparently do not include peat mining, but rather maintaining the area as a lake. If this is so, any sediment and nutrient loading received by this lake will likely not be exported to Fish Creek.

Peat Mining

The Cranberry Bog at County Roads 75 South and 775 East was drained for peat mining beginning in 1968 and continuing through 1990. Before peat mining commenced, the bog area was fed by ground water as well as by direct surface runoff. The culvert under County Road 775 East was probably installed to drain surface water from the bog and certainly pre-dates drainage and mining operations in the bog. Peat bogs of this type are areas of saturated organic material without surface drainage flow. There were probably no major drainage outflows from the bog before mining, therefore only very limited amounts of sediment and nutrients would have entered Fish Creek from this source. When the bog was drained for mining, however, the watershed of Fish Creek was increased by the watershed area of the bog. The Cranberry Bog watershed is approximately 980 acres, about 35% of the Fish Creek watershed and about 15% of the total Fish Lake watershed (Figure 3).



Watershed Area for Cranberry Bog



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Wetland Delineation • Environmental Permitting
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A representative of Millburn Peat Company stated that an National Pollutant Discharge Elimination System (NPDES) permit was issued about the time mining commenced. The mining operation was not registered with the IDNR Division of Water under the Water Resources Management Act as a facility capable of discharging 100,000 gallons per day. Water was pumped from the east side of the bog through a culvert under County Road 775 East, then northeast to the west branch of Fish Creek at a point about 1.8 miles above Fish Lake. Maximum pump capacity was reportedly 24,000,000 gallons per day. This volume of water equals 73.6 acre-feet per day or 37.1 cubic feet per second. A more conservative estimate of maximum drainage capacity was based on the size of the culvert under Road 775 East. Depending on the slope of the buried tile, the capacity could range from 10 to 15 cubic feet per second or 6.5 to 10 million gallons per day.

Other peat mining sites include the area between County Roads 775 East and 875 East, on both sides of County Road 75 South. This area is operating under an IDNR permit and is strictly a dragline operation with peat stockpiled on an adjacent upland site. No water is discharged into the existing adjacent drainage ditches. Another peat mining operation in the west half of Section 10 (T-36N, R-1W), north of the railroad tracks. This intermittent operation has not been active for the past two years. Permits stipulate that no peat material, overburden or spoil may be placed in wetland areas.

Problems associated with peat mining include particulate matter (peat) in drainage water, increased wind and water erosion of exposed peat surfaces and streambed erosion due to increased water volume and velocity, especially in areas of organic soils.

The sediment model described in the final feasibility report (Crisman, 1990) estimated that under existing conditions the annual storm event Fish Creek would contribute 744 tons, with 55 tons coming from the 296 acre Cranberry Bog sub-basin. The elimination of sediments from peat mining activities was predicted to reduce sediment loadings to Fish Creek by 7%, but only with effective land reclamation at these sites. It was estimated that utilization of no-till farming practices on all areas of highly erodible soil, sediment loading to Fish Creek would be reduced by 66% or 468 tons per annual storm event.

The sediment deltas have increased the area of shallow water, and this "new land" has been colonized by purple loosestrife. The effects of these changes are discussed later in this report.

Stream Channels

The Fish Creek watershed is naturally protected by wide areas of hydric soils and wetlands which detain and slowly release large amounts of stormwater. Peat mining in Cranberry Bog, however, dramatically increased the flow of the creek by pumping water into the creek bypassing the protective wetlands. To accommodate these substantial increased flows, the stream would have undergone a period of adjustment in which the channel was scoured causing widening and/or deepening. Some changes in the stream channel can be seen in aerial photographs from 1958, 1981 and 1986. These are represented in Figure 4. The most obvious change seen is the cutting off of several oxbows. However, there is no way to determine if these changes would have occurred naturally or are the result of increased flows. Stream flow and velocity are, however, important factors in determining stream sinuosity and length. Unfortunately, premining information on stream channel width and depth does not exist to allow comparison with present conditions as aerial photography does not show sufficient detail.

Future Plans for the "Cranberry Bog"

According to Millburn Peat Company, peat mining in the Cranberry Bog has been terminated. In 1991 water levels in the bog were allowed to rise to the level of the installed outlet structures. The ditch between the overflow structure and the culvert under County Road 775 East has been blocked with a temporary earthen dam. The site is reportedly for sale, presumably for residential development. Most importantly, this area will no longer discharge water, nutrients and sediments into Fish Creek.

Peat Mining Regulations

The regulations governing excavating, filling and dredging in lakes and wetlands are an important defense of water quality. To better guide the Fish Lake community, the regulatory agencies were contacted and asked what laws would regulate "surface peat mining."

United States Army Corps of Engineers

Under authority of Section 404 of the Clean Water Act, the Corps of Engineers has jurisdiction over all waters of the United States, including all wetlands. The present interpretation of the Clean Water Act is to regulate fill material placed in wetlands. Therefore, if a peat mining operation were begun today, no permit would be required from the Corps of Engineers if the bog was dewatered by ditching and draining, as long as the ditch spoil and mined peat were placed on an upland area. A mining operation using a dragline would not require a permit as long as the peat was deposited on an

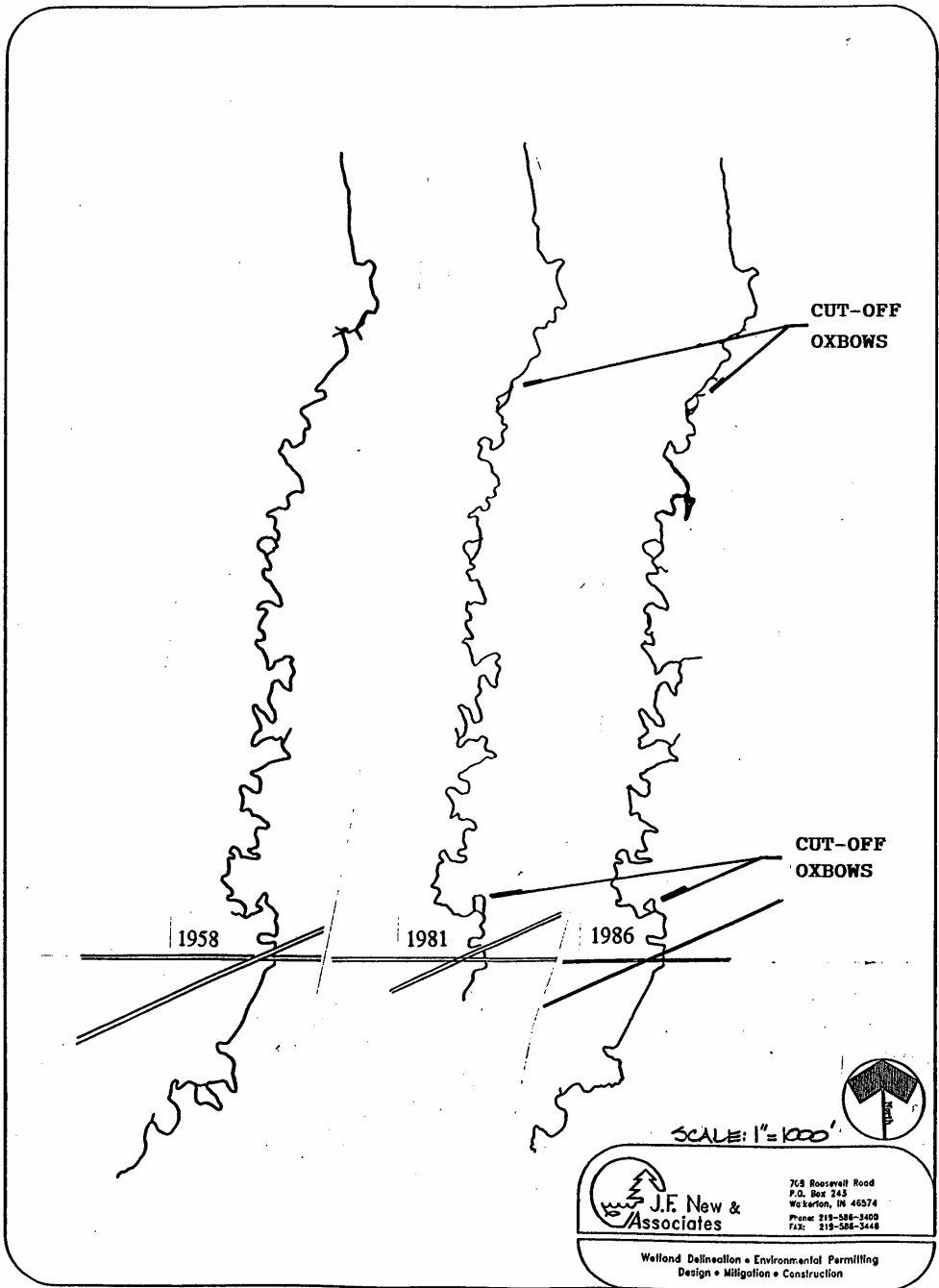


FIGURE 4

upland area. On the other hand, a permit would be required from the Corps of Engineers if a dragline was used to remove peat from an undrained area and place it in a jurisdictional wetland.

United States Environmental Protection Agency

Section 404 of the Clean Water Act is actually an Environmental Protection Agency (EPA) regulation. Traditionally, the Department of the Army, Corps of Engineers exercises jurisdiction, but the EPA can and often does overrule the Army and take authority in an individual case.

Indiana Department of Environmental Management

The Indiana Department of Environmental Management (IDEM) administers Section 401 of the Clean Water Act and has authority over the discharge of pollutants (including dredged materials such as peat) into water and wetlands. Like the Corps of Engineers, IDEM is concerned with the discharge of material into water, not removing material from water.

Indiana Department of Natural Resources, Division of Water

The Indiana Department of Natural Resources has jurisdiction over the Fish Lake watershed by authority of several regulations:

The Water Resources Management Act (IC 13-2-6.1) requires all significant water withdrawal facilities to be registered with the IDNR. A significant water withdrawal facility is defined as having the capability of withdrawing more than 100,000 gallons of ground water and/or surface water per day.

Section 13-2-11.1 of the Indiana Code regulates activities in public fresh water lakes. This law governs dredging and filling within the legally established water levels of the lake (688.22 feet, mean sea level) and changing the shoreline or bed of the lakes. All seawall construction, lake-front dredging and filling must have IDNR approval prior to construction.

Section 13-2-15-1 of the Indiana Code deals with the drainage laws. A permit from the Indiana Department of Natural Resources is required for constructing, repairing or recleaning "any ditch or drain having a bottom depth lower than the normal water level of a fresh water lake of ten acres or more and within one-half mile of the lake."

Section 13-2-22-13 addresses flood control and prohibits placement of "any structure, obstruction, deposit, or excavation in or on any floodway...which will adversely affect the efficiency of or unduly restrict the capacity of the floodway or which...will constitute

an unreasonable hazard to the safety of life or property, or result in an unreasonable detrimental effects upon the fish, wildlife, or botanical resources, and the same are declared to be and to constitute public nuisances."

Indiana Department of Natural Resources, Division of Nature Preserves

The Indiana Chapter of The Nature Conservancy owns a 47-acre property along Fish Creek. Fish Creek Fen Nature Preserves is a very high quality, fragile, natural area and should be protected from dredging, filling or peat mining.

LaPorte County Drainage Board

The LaPorte County Surveyor confirmed that the only county drain in the Fish Lake watershed is Sharp Ditch corresponding to that part of Mill Creek from approximately one-quarter mile north of Division Road downstream to Upper Fish Lake (Figure 5). LaPorte County maintains a 75-foot wide right-of-way on each side of the centerline of the ditch. Any work in the legal drain must first be approved by the LaPorte County Drainage Board as well as the Indiana Department of Natural Resources.

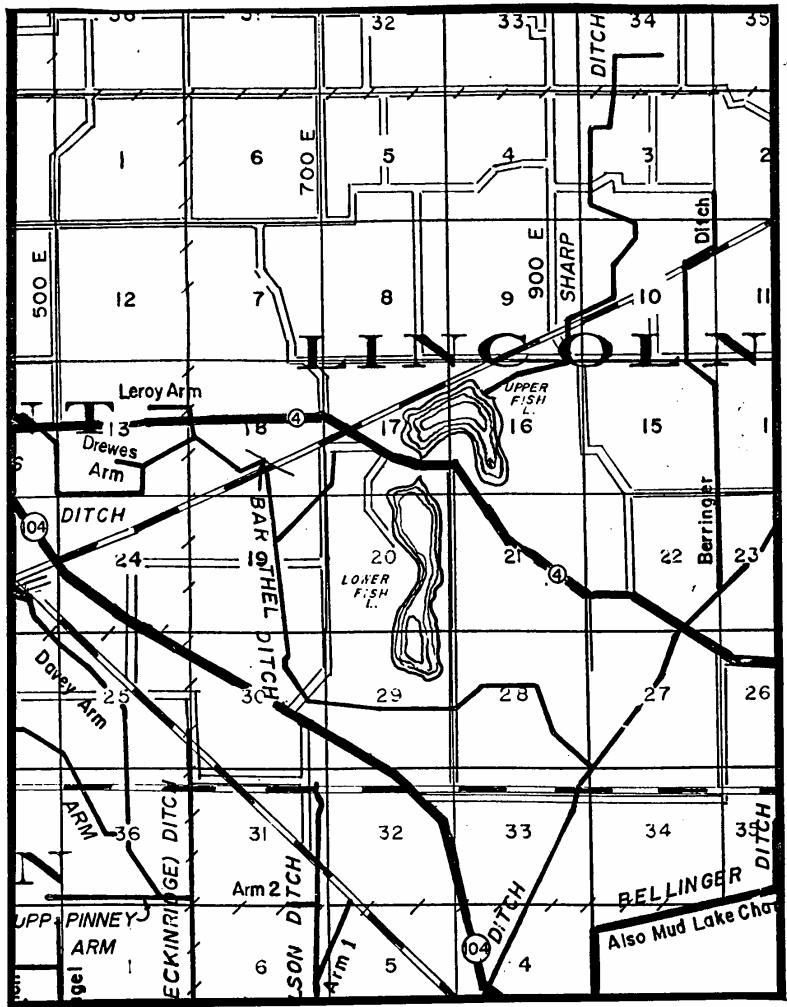
The addresses and telephone numbers of these agencies are listed in Appendix D.

Livestock Operations

No other point-source facilities such as large scale livestock feedlots are located in the Fish Lake watershed. The several small dairy and cow-calf herds appear to have abundant pasture area, and animal waste is not concentrated in small, unvegetated feedlots. This is a serious problem in other watersheds, where feedlots and holding areas are sited on hillsides for good drainage, or where livestock have unlimited access to an unprotected stream for drinking water. In these cases, the stream receives large volumes of sediment and nutrients. Again, there are no "hot spots" of animal waste in the Fish Lake watershed.

Other Influences

There is little residential or commercial construction on Fish Lake which could be a source of sediment runoff during heavy rainfall.



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WATER QUALITY SURVEY

WATER QUALITY SURVEY

Water quality sampling sites were chosen in order to identify potential "hot spots" of high levels of sediment and/or nutrient runoff which would potentially contribute to problems in the Fish Lake system. A long-term decline in water quality has been documented by Indiana Department of Natural Resources fish management surveys since 1969. This decline is evidenced by decreased clarity and changes in water color.

Turbidity Measurements in Fish Lake, IDNR

<u>YEAR</u>	<u>WATER COLOR</u>	<u>SECCHI DISK</u>
1969	Clear	11' 0"
1974	Clear	9' 0"
1975	Brown	3' 6"
1976	Greenish-Blue	6' 3"
1978	Brown	7' 6"
1984	Brown	4' 0"

Methods

Water quality samples were taken from 11 stations at inflows to Lower and Upper Fish Lakes as well as several points on Fish and Mill Creeks (Figure 6) on April 15 and June 18, 1991. Inflow samples were taken at the sheet flows or where small braided channels flowed through the vegetated deltas. The idea was not to sample lake water but to sample water as it entered the lake. In-lake sampling was conducted in previous studies.

Grab samples were collected and kept on ice until delivered to Environmental Testing of LaPorte County for analysis. Unless otherwise stated, the method numbers referred to here are those found in *Standard Methods for the Examination of Water and Wastewater, 17th Edition* (Clesceri et al. 1989). Water samples were analyzed for:

1. BOD₅ - biological oxygen demand. BOD₅ is the measure used to describe the rate of oxygen consumption by organisms over a five day period. BOD₅ was measured by the standard 5-day BOD Test (5210 B). The initial (Day 1) and final (Day 5) oxygen levels were determined with the azide modification (4500-O C) of the iodometric method (4500-O B). This method has a precision of 20 µg/liter in distilled water with no interferences present.

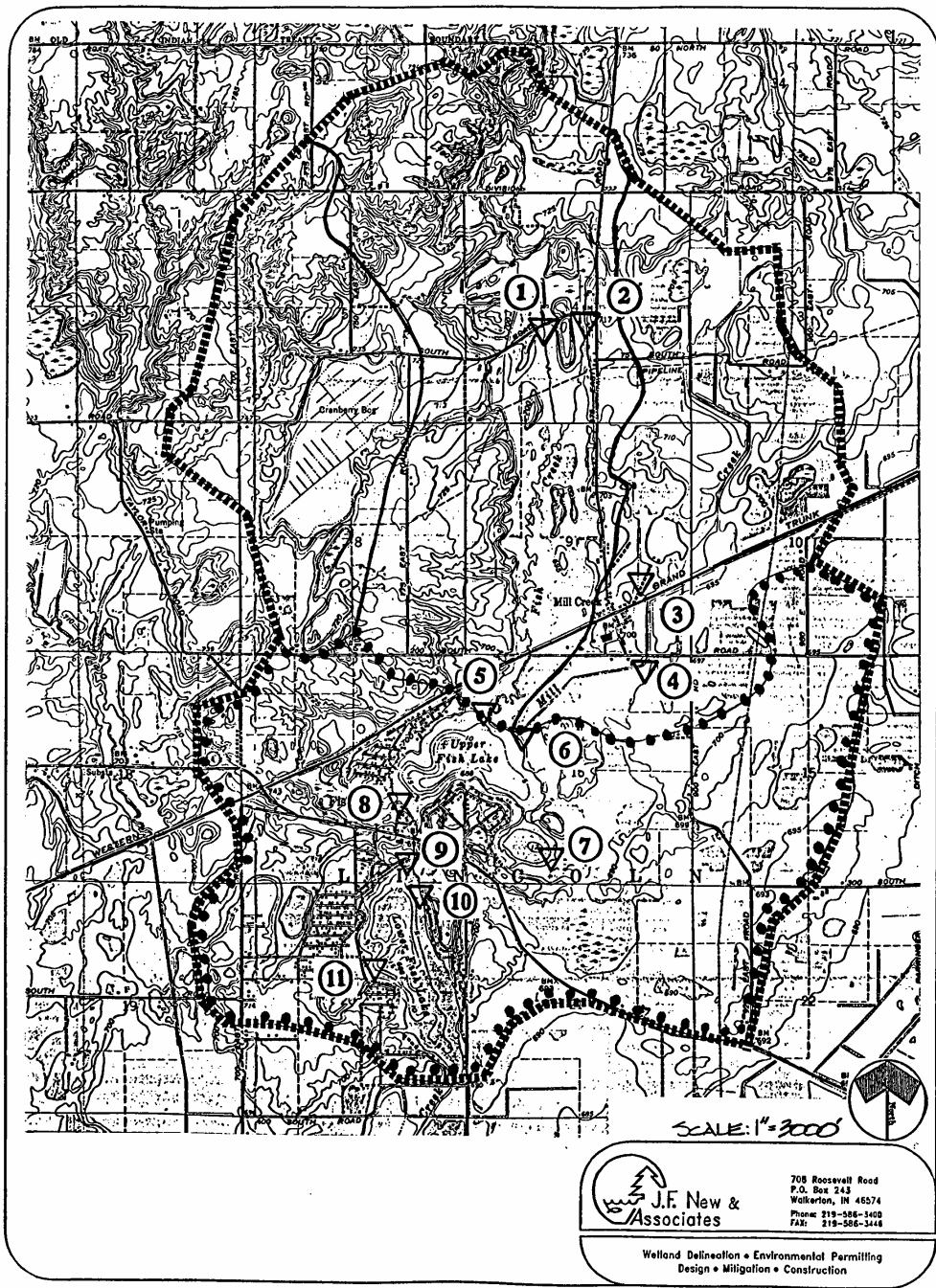


FIGURE 6

2. TSS - total suspended solids. TSS is a measure of the particulate matter within the water column. This can consist of inorganic as well as organic materials. TSS was measured using method 31-1159 adapted from *Sewage and Industrial Wastes* (Clesceri, 1989). The detection limit was 1.0 $\mu\text{g/liter}$.
3. TKN - total kjeldahl nitrogen. TKN is a measurement of free ammonia and organic nitrogen. It is a good measure of nitrogen immediately available for plant use. The samples were prepared by digestion and distillation (4500-N_{org} B). The ammonia nitrogen was then measured by the Nessler method (4500-NH₃ C). The detection limit for the equipment used was 1.0 $\mu\text{g/liter}$.
4. TP - total phosphorus. TP is a measure of the total phosphorus within the system and includes orthophosphorus, hydrolyzable phosphorus, and organic phosphorus. Only the orthophosphorus component is immediately available for use by plants. Other components, however, can become available through biological or chemical decomposition. Samples were acid digested (4500-P B) and phosphorus was then measured using the ascorbic acid method (4500-P E). The detection limit for the equipment used was 0.01 $\mu\text{g/liter}$.

Results and Discussion

The water quality sampling design originally called for two sampling efforts: one during spring base flows and a second after a large spring storm event. Because of drought conditions, however, there was no large storm event and the second set of samples was taken during very low flows in June. We were therefore not able to obtain samples to quantify the transport of particulate matter and nutrients during high flow storm conditions. The results should therefore be considered to represent minimum transport conditions.

The results of the two water quality sampling efforts can be found in Table 1. The April sampling occurred during the period of moderate spring base flows while the June sampling occurred during a period of record drought and extremely low base flows. The extremely dry conditions caused several problems for the June sampling. Station 11 could not be sampled because there was no inflow of water. Also, BOD₅ analyses for several sites were anomalous and so are not presented. Dr. Joseph Camp of Environmental Testing of LaPorte County felt this may have been due to low dissolved oxygen levels and low water flow. Each of these sample stations was characterized by thin (less than 1 inch deep) sheet flow of water over highly flocculent organic sediments.

FISH LAKE WATER QUALITY DATA - 4/15/91

Sample Station	BOD (mg/l)	TSS (mg/l)	TKN (mg/l)	TP (mg/l)
1 Fish Creek west trib. 75 S.	1.4	5.0	6.7	0.05
2 Fish Creek east trib. 75 S.	3.7	5.0	2.1	<0.01 ³
5 Fish Creek at inlet	1.6	5.0	1.3	0.004
3 Mill Creek at railroad	1.7	6.0	2.1	<0.01 ³
4 Mill Creek at 200 South	1.8	8.0	2.5	0.08
6 Mill Creek at inlet	2.0	15.0	2.5	0.02
7 Mud Lake, east shore	4.9	6.0	2.1	<0.01 ³
8 Upper Lake, west side	2.5	8.0	0.8	<0.01 ³
9 Lower Lake, northeast side	1.3	7.0	1.7	<0.01 ³
10 Lower Lake, northeast side	2.2	4.0	2.1	<0.01 ³
11 Lower Lake, west side	2.0	9.0	2.1	<0.01 ³

FISH LAKE WATER QUALITY DATA - 6/18/91

Sample Station	BOD (mg/l)	TSS (mg/l)	TKN (mg/l)	TP (mg/l)
1 Fish Creek west trib. 75 S.	--- ¹	2.0	3.8	0.01
2 Fish Creek east trib. 75 S.	1.4	4.5	1.3	0.03
5 Fish Creek at inlet	--- ¹	0.5	0.9	<0.01 ³
3 Mill Creek at railroad	0.5	9.0	0.8	0.40
4 Mill Creek at 200 South	1.4	2.5	0.9	0.06
6 Mill Creek at inlet	--- ¹	2.0	1.1	<0.01 ³
7 Mud Lake, east shore	4.0	10.5	2.9	0.09
8 Upper Lake, west side	--- ¹	3.0	1.1	<0.01 ³
9 Lower Lake, northeast side	--- ¹	2.0	1.3	0.02
10 Lower Lake, northeast side	--- ¹	0.0	1.1	0.05
11 Lower Lake, west side	--- ²	--- ²	--- ²	--- ²

¹ BOD samples from six stations were anomalous and so are not reported. A discussion of this is found in the text.

² Station 11 was dry, so samples could not be taken.

³ Below detection limits

Disturbance of these sediments while obtaining a sample may have resulted in samples being contaminated with anoxic organic sediments. The Total Suspended Solids (TSS) and other parameters could also have been affected by these sampling conditions. Examination of the water quality data reveals no clear overall pattern of results. No station had a consistently high or low pattern of results either between sampling dates across parameters with the exception of the June 1991 Mud Lake inflow samples (station 7). These were relatively high for all parameters (Figures 7-10) during that sampling period.

TSS values in most cases were generally low (Figure 7). Only two stations, Mill Creek inlet (station 6, April, 15.0 mg/L) and Mud Lake inlet (station 7, June, 10.5 mg/L) had values greater than 10 mg/L. June data generally exhibited lower TSS values than the April data. The extremely low flow rates encountered undoubtedly played a role in reducing TSS.

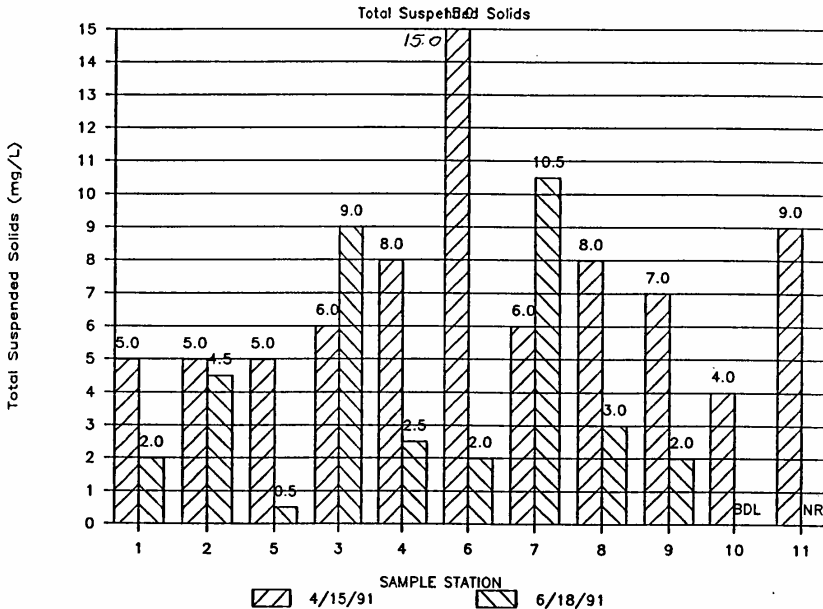
TP ranged from below detection limits (<0.01 mg/L) to 0.40 mg/L though all but one station was below 0.09 mg/L (Figure 8). TP was highest at the upstream Mill Creek sampling station (station 3). TP was reduced, however, from 0.40 mg/L at station 3 to below detection limits at the Mill Creek inlet (station 6). Livestock in this area may have been a factor in high TP at this station.

BOD₅ for the sites ranged from 0.5 to 4.9 mg/L, none of which should be considered high. In all cases where data was available for both sampling dates, BOD₅ was lower for the June sampling period (Figure 9).

TKN ranged from 6.7 to 0.8 mg/L (Figure 10). Station 1 (Fish Creek and 75 South) displayed the highest TKN for both sampling periods (6.7 and 3.8 mg/L respectively). These were both greatly reduced, however, at the Fish Creek inlet (station 5, 1.3 and 0.9 mg/L respectively). Mill Creek, however, showed no pattern of upstream to downstream TKN reduction. With the exception of stations 7 and 8, TKN was reduced in the June sampling period.

Stations 7-11, which represent minor tributaries to the Fish Lake system generally exhibited water quality similar to that of Fish Creek and Mill Creek. Because of their small, and in some cases intermittent, water volume contributions to the lake in comparison to Fish and Mill Creeks they are probably not a significant factor affecting water quality at this time. If in the future other nutrient and sediment sources are reduced sufficiently it may be necessary to address these tributaries.

INFLUENT WATER QUALITY DATA



FISH CREEK WATERSHED SAMPLE STATIONS:

- 1 West tributary to Fish Creek at County Road 75 South
- 2 East tributary to Fish Creek at County Road 75 South
- 5 Fish Creek outlet to Upper Fish Lake

MILL CREEK WATERSHED SAMPLE STATIONS:

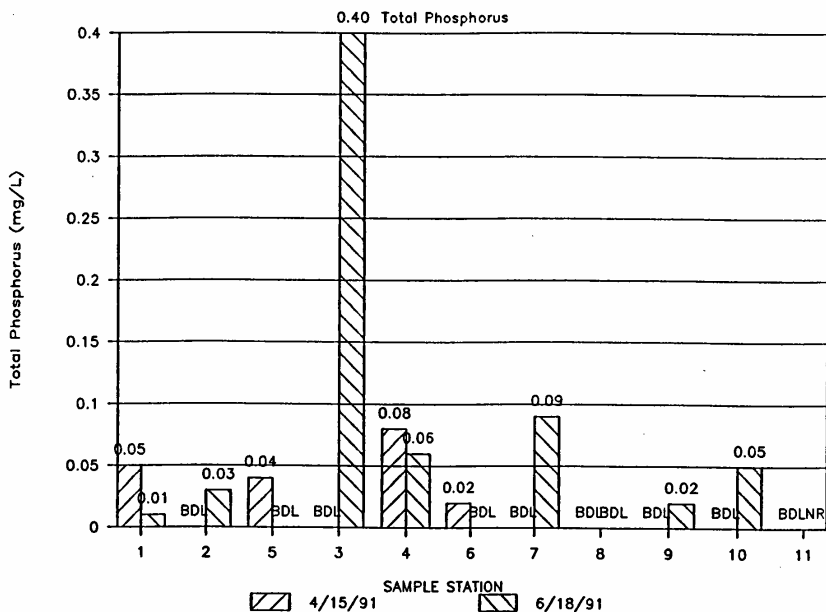
- 3 Mill Creek at Grand Trunk Railroad bridge
- 4 Mill Creek at County Road 200 South
- 6 Mill Creek outlet to Upper Fish Lake

LOWER FISH LAKE WATERSHED SAMPLE STATIONS:

- 7 East shore of Mud Lake
- 8 West shore of Upper Fish Lake
- 9 Channel outlet to Lower Fish Lake
- 10 Northeast shore of Lower Fish Lake
- 11 West shore of Lower Fish Lake

FIGURE 7

INFLUENT WATER QUALITY DATA



FISH CREEK WATERSHED SAMPLE STATIONS:

- 1 West tributary to Fish Creek at County Road 75 South
- 2 East tributary to Fish Creek at County Road 75 South
- 5 Fish Creek outlet to Upper Fish Lake

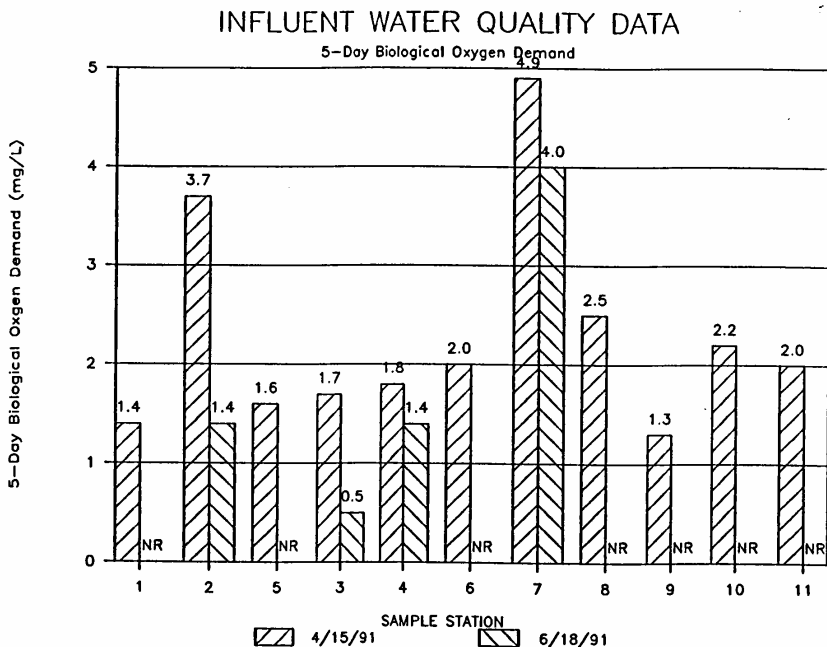
MILL CREEK WATERSHED SAMPLE STATIONS:

- 3 Mill Creek at Grand Trunk Railroad bridge
- 4 Mill Creek at County Road 200 South
- 6 Mill Creek outlet to Upper Fish Lake

LOWER FISH LAKE WATERSHED SAMPLE STATIONS:

- 7 East shore of Mud Lake
- 8 West shore of Upper Fish Lake
- 9 Channel outlet to Lower Fish Lake
- 10 Northeast shore of Lower Fish Lake
- 11 West shore of Lower Fish Lake

FIGURE 8



FISH CREEK WATERSHED SAMPLE STATIONS:

- 1 West tributary to Fish Creek at County Road 75 South
- 2 East tributary to Fish Creek at County Road 75 South
- 5 Fish Creek outlet to Upper Fish Lake

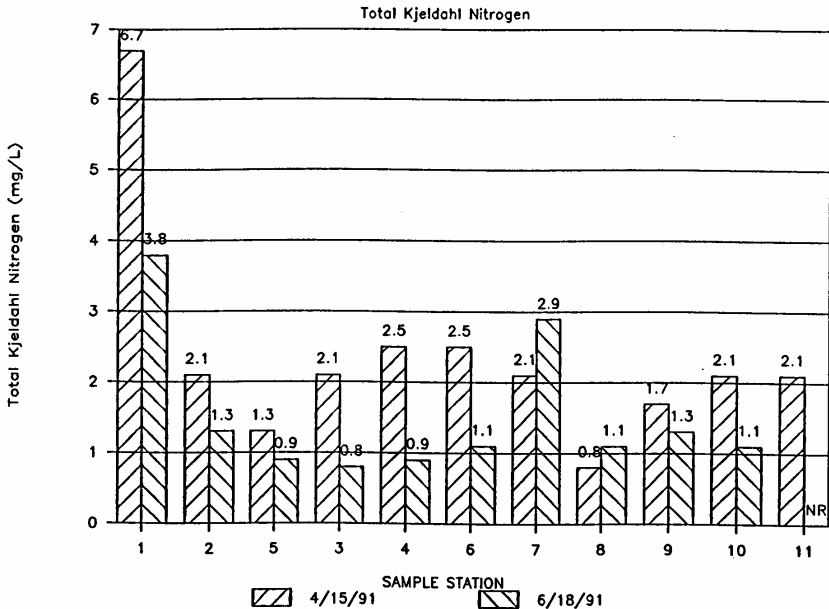
MILL CREEK WATERSHED SAMPLE STATIONS:

- 3 Mill Creek at Grand Trunk Railroad bridge
- 4 Mill Creek at County Road 200 South
- 6 Mill Creek outlet to Upper Fish Lake

LOWER FISH LAKE WATERSHED SAMPLE STATIONS:

- 7 East shore of Mud Lake
- 8 West shore of Upper Fish Lake
- 9 Channel outlet to Lower Fish Lake
- 10 Northeast shore of Lower Fish Lake
- 11 West shore of Lower Fish Lake

INFLUENT WATER QUALITY DATA



FISH CREEK WATERSHED SAMPLE STATIONS:

- 1 West tributary to Fish Creek at County Road 75 South
- 2 East tributary to Fish Creek at County Road 75 South
- 5 Fish Creek outlet to Upper Fish Lake

MILL CREEK WATERSHED SAMPLE STATIONS:

- 3 Mill Creek at Grand Trunk Railroad bridge
- 4 Mill Creek at County Road 200 South
- 6 Mill Creek outlet to Upper Fish Lake

LOWER FISH LAKE WATERSHED SAMPLE STATIONS:

- 7 East shore of Mud Lake
- 8 West shore of Upper Fish Lake
- 9 Channel outlet to Lower Fish Lake
- 10 Northeast shore of Lower Fish Lake
- 11 West shore of Lower Fish Lake

Table 2 compares results from the 1988 water quality studies with sample results from 1991. Care should be exercised in making direct comparisons between the data sets, however, because of minimal sample sizes and uncontrolled water velocities. Also, only the 5/88 and 4/91 sampling efforts occurred in a similar time of year. The most encouraging comparison is the apparent reduction in Total Suspended Solids (TSS) in Fish Creek and Mill Creek. Particulate matter in 1991 was less than half the levels of 1988 for the comparable spring sampling dates (Figure 11). The cessation of mining in Cranberry Bog may account for the decrease of TSS in Fish Creek but would not account for the large decrease in Mill Creek. The reduction may therefore be due to other factors such as the record drought conditions in 1991 or sampling variations. With the exception of one date, TP shows no real change from 1988 to 1991 (Figure 12) while the BOD₅ data may indicate a decrease (Figure 13). The BOD₅ data, however, is very spotty and should be viewed with caution. The TKN data (Figure 14) may indicate a decrease in water quality but, again, the data is incomplete and should be compared with caution. Overall, the data do not appear to show a clear pattern of increase or decrease in water quality from 1988 to 1991.

COMPARISON OF 1988 and 1991 WATER QUALITY TEST RESULTS

WATERSHED LOCATION	SAMPLE DATES AND POINTS	BOD ₅	TOTAL SUSPENDED SOLIDS	TOTAL KJELDAHL NITROGEN	TOTAL PHOSPHORUS
Fish Creek Upper Watershed	5/23/88 (at Peat Bog)	4.0	13	---	0.04
	4/15/91 (west tributary at	1.4	5.0	6.7	0.05
	6/18/91 County Road 75 South)	---	2.0	3.8	0.01
Fish Creek Lower Watershed	5/23/88 (County Road 200 South)	3.0	14	---	0.28
	8/10/88	7.0	1	0.29	0.02
	9/19/88	---	4	<0.05	0.05
	4/16/91 (at outlet to Upper	1.6	5.0	1.3	0.04
	6/18/91 Fish Lake)	---	2.0	0.9	<0.01
Mill Creek County Road 200 South	5/23/88	3.0	28	---	---
	9/19/88	---	24	<0.05	0.05
	4/15/91	1.8	10.0	2.5	0.08
	6/18/91	1.0	4.5	0.9	0.06

Different sampling points were used in the 1988 and 1991 water quality studies, thus results are not directly comparable. The 1988 sampling locations and methods are described here for the reader's information.

TABLE 2

WATER QUALITY DATA: 1988 vs 1991

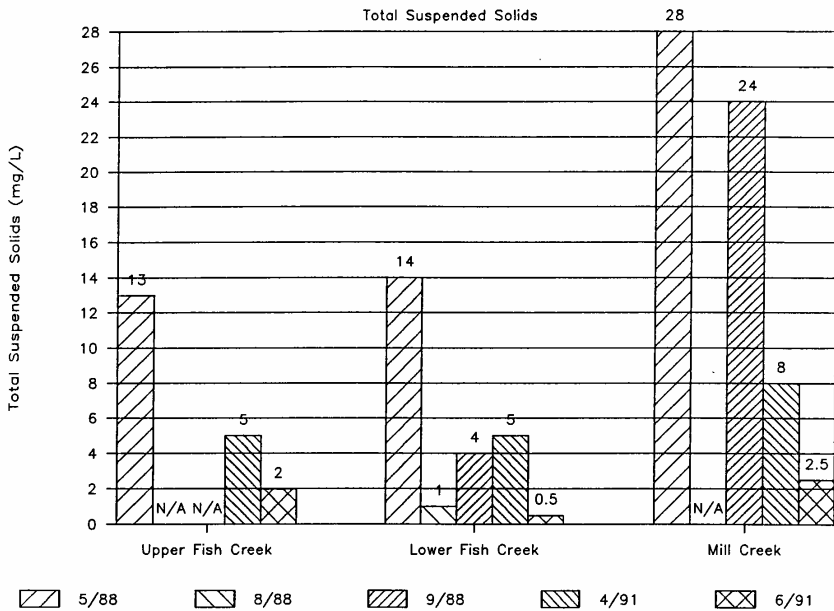


FIGURE 11

WATER QUALITY DATA: 1988 vs 1991

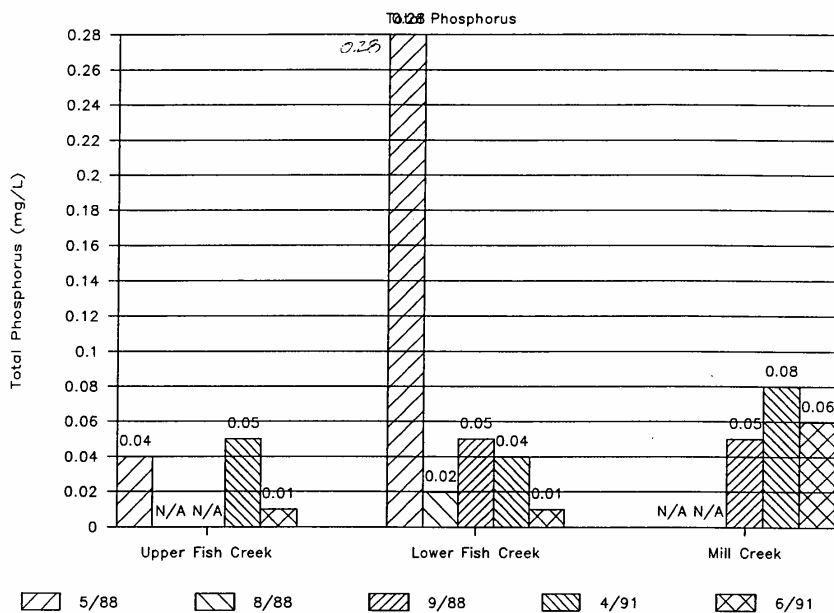


FIGURE 12

WATER QUALITY DATA: 1988 vs 1991

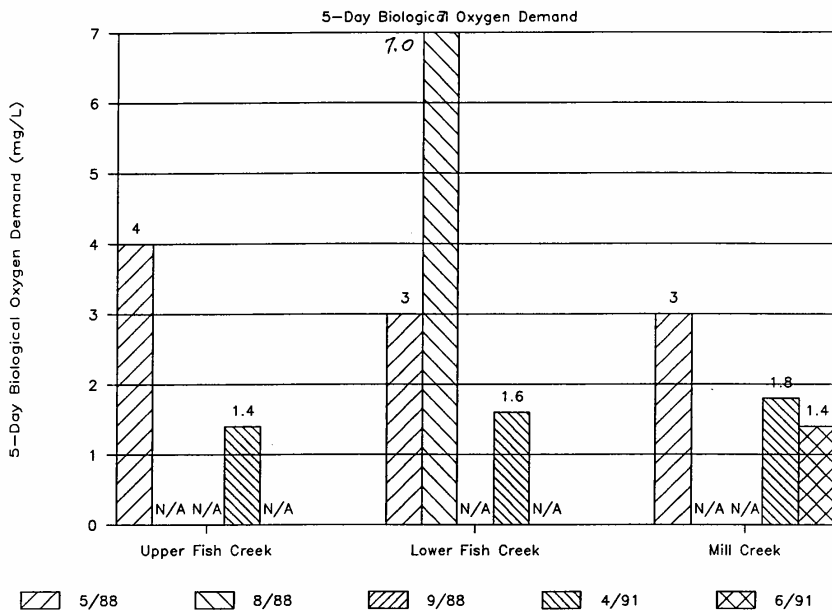


FIGURE 13

WATER QUALITY DATA: 1988 vs 1991

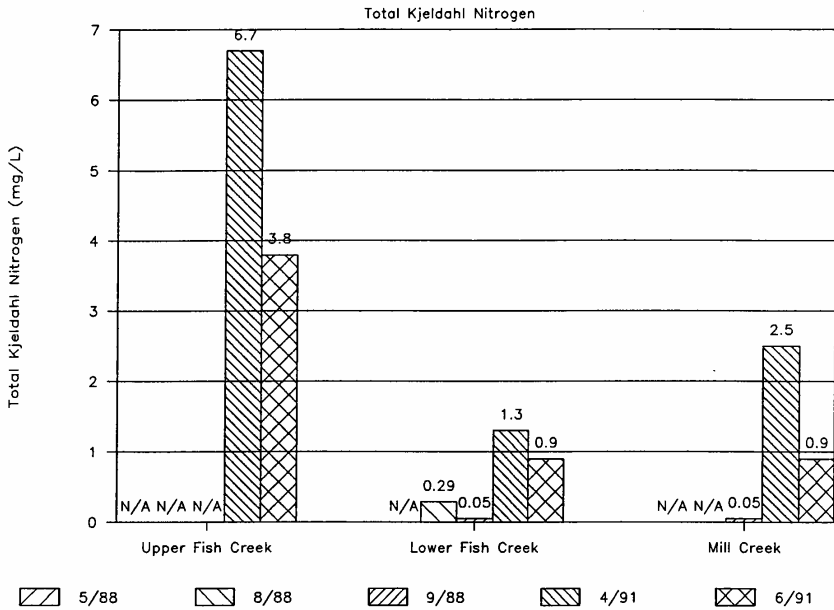


FIGURE 14

SEDIMENT CORING AND BATHYMETRIC STUDY

SEDIMENT CORING AND BATHYMETRIC STUDY

Over time, sediment from Fish Creek and Mill Creek have formed deltas at the upper end of Fish Lake. These areas act as "nutrient banks" which collect nutrient laden sediment during periods of low water flow. High water flows flush the sediment out into the lake where it is available to macrophytes and algae, causing nuisance weed growth. One goal of the Fish Lake study was to determine the volume of sediment in these deltas and to assess the need for sediment removal, stabilization or other lake restoration techniques. Volume estimates were made through a limited bathymetric and sediment coring survey of parts of Upper Fish Lake.

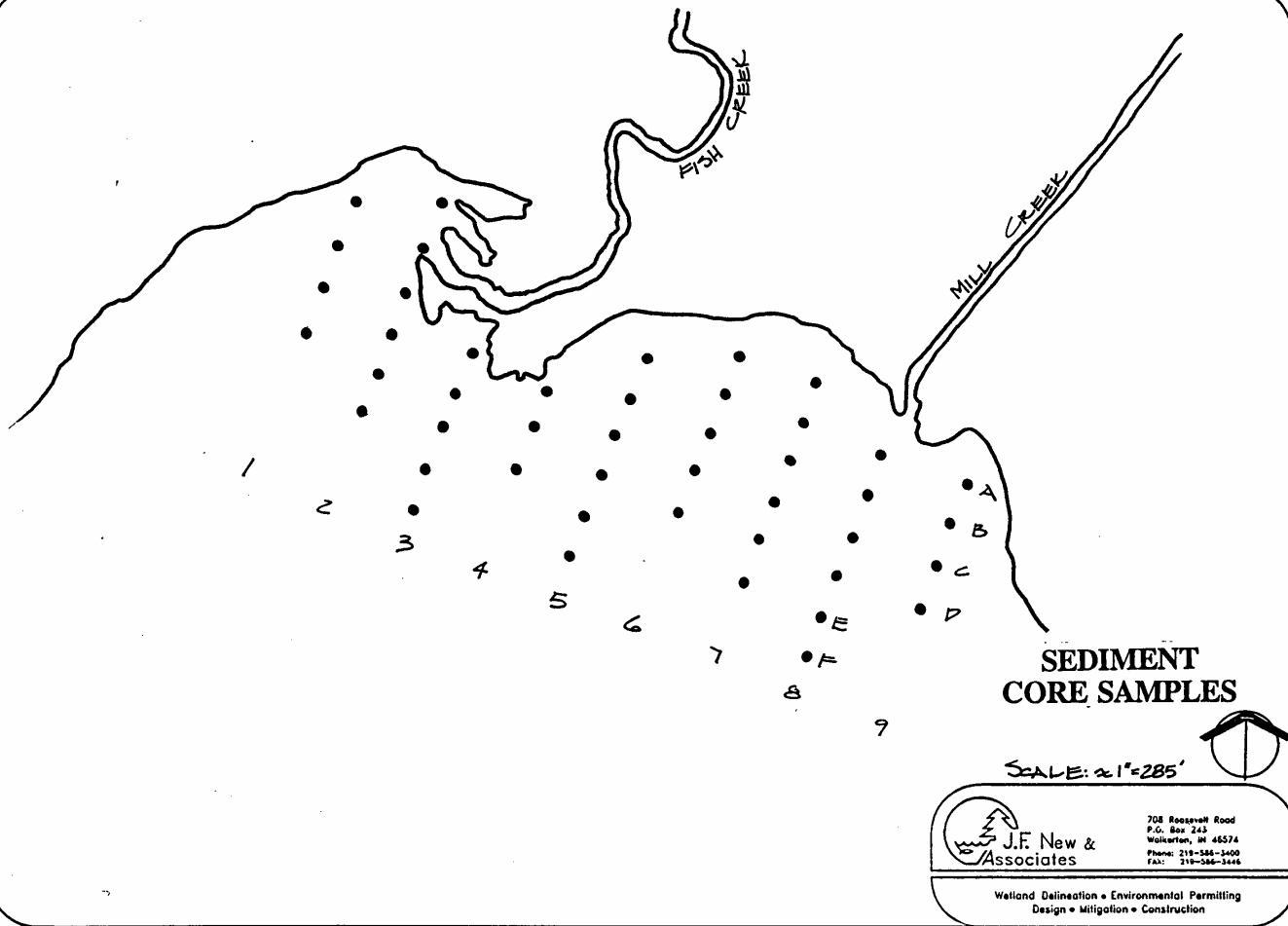
Methods

A limited bathymetric survey of Upper Fish Lake was carried out in conjunction with sediment coring. Forty-six sediment cores were taken (Figure 15) in order to determine the present and historic lake bottom. The cores were taken in a series of 9 transects from west side of the Fish Creek inlet to east of the Mill Creek inlet. The transects were spaced 200 feet (\pm) apart and core samples within each transect were taken at intervals of 100 feet (\pm). Forty of the cores were taken working on the frozen lake on February 9 and 10, 1991. The six remaining cores could not be taken at that time due to thin ice. These were taken on May 24, 1991 working from a boat.

Cores were taken by driving a 1.5 inch diameter graduated PVC pipe into the lake bottom. A vacuum was then created within the sampling tube to prevent the core from being lost as the tube was drawn to the surface. The sediment core was then extruded from the tube using a piston. The following was noted for each core: depth to top of sediment, depth to bottom of sample, compressed thickness, and a short description of the sediment profile noting the thickness and composition of various layers. The results are presented in Appendix C.

From this information estimates were made of the depth to the "historic" lake bottom by calculating the depth of the new sediments and adding that to the current depth. The depth of the recent sediments was estimated by subtracting the portion of the sediment core made up of original bottom material from the total length of the uncompressed sample profile. This assumes that most of the sample compression occurs within the newer, unconsolidated sediments. This is a reasonable assumption considering that the original bottom material was found to generally be fibrous peat, clay, muck, or marl. These compress little while being extruded from the coring tube in comparison to the flocculent

FIGURE 15



newer sediments. Variable compression loads may, however, be a source of error in using this method. The determination of what were new and old sediments was made by comparing color, texture, firmness, and composition of layers within a profile.

Results and Discussion

Core samples revealed that the sediments forming the deltas at the mouths of Fish and Mill Creeks are highly organic and flocculent in nature (Table 3). While this study did not specifically analyze sediment samples, the draft report by Turnbell (1989, Table 14) reported that sediments at the mouths of Fish and Mill Creeks were 57.0 and 30.7 % organic respectively. The higher organic content of the Fish Creek delta sediments may be the result of upstream peat mining which occurred in that watershed.

The new delta sediments can be best described as a flocculent sapric peat material. While most of the organic sediments are decomposed beyond recognition, some relatively undecomposed plant material is present (Table 3) indicating, perhaps, the highly anoxic nature the sediments. These larger, relatively undecomposed fragments may be derived from in-lake sources where they were protected from rapid decomposition and structural fragmentation processes which occur in stream systems. While in-lake sources of organic material have undoubtedly contributed to the formation of the deltas the formation of the sediment deltas at the inlet streams indicates that sediment transport from external sources is the primary causative factor. In-lake sources will likely become more important in the future development of the deltas as more woody or cellulose rich (i.e. dense) wetland plants replace the relatively structureless (i.e. less dense) aquatic plants.

Core sample compression of the new sediments averaged 72%, indicating the very flocculent nature of the new sediments. In many areas along the northern shore of Upper Fish Lake the water depth may be only two inches deep but a firm bottom is not reached for five or more feet. The average compression for samples taken from the Mill Creek delta (Table 3, Transects 6-9) was 88% while the Fish Creek samples (Table 3, Transects 1-5) averaged only 61%. Fish Creek may, because of higher flows, carry heavier, larger sediment particles. This would result in sediments which settle faster. Increased flows during peat mining and scouring of the Fish Creek channel would have also resulted in heavier particles being transported into the lake. The draft Turnbell report (1989, Table 14) reported that sediment particles from the Fish Creek delta are, in fact, larger than those of the Mill Creek Delta. Apparent differences in sediment may also be due to source differences. Water pumped from Cranberry Bog may have carried elevated amounts of peat fragments. Unfortunately no water samples were taken while the peat mine was in operation to confirm this.

SAMPLE STATION	CURRENT LAKE BOTTOM	ORIGINAL LAKE BOTTOM	NEW SEDIMENT THICKNESS	COMPRESSED SEDIMENT THICKNESS	COMPRESSED AS PERCENTAGE OF ORIGINAL	DESCRIPTION OF NEW SEDIMENTS (top to bottom)
1 A B C	1.8 ft. 2.4 2.6	1.8 ft. 2.4 + 2.6	None None None			Shelly peat (original bottom) Shelly peat (original bottom) Sandy clay with some shells (original bottom)
2 A B C D E F	0.5 ft. 1.7 1.3 2.2 4.6 11.3	5.0 ft. 2.8 3.5 3.7 9.6 ---	4.5 ft. 1.1 2.2 1.5 1.4 ---	1.0 ft. 0.5 0.3 0.3 0.4 ---	22.2 % 45.5 13.6 20.0 28.6	Flocculent sapric peat, undecomposed veg. Flocculent black fibrous peat, some shells Flocculent sapric peat Flocculent sapric peat Loose sapric peat with some shells
3 A B C D E F	0.3 ft. 1.5 2.6 6.5 11.6 12.0 +	8.2 ft. 6.9 8.6 10.8 + --- ---	7.9 ft. 5.4 6.0 4.3 --- ---	1.8 ft. 1.4 1.2 1.7 --- ---	22.8 % 25.9 20.0 39.5	0.3' Flocculent sapric peat, 0.2 loose peat 1.3' black and gray organic matter 0.7' Flocculent peat, 0.7' firm organic matter with undecomposed vegetation, fibers Flocculent sapric peat Flocculent sapric peat -----
4 A B C D	1.3 ft. 1.3 4.7 8.5	8.0 ft. 6.8 10.0 11.5 +	6.7 ft. 5.5 5.3 3.0	1.6 ft. 1.8 1.5 1.3	23.8 % 32.7 28.3 43.3	0.5' Flocculent peat, 1.1' brown/black peat with undecomposed fibers and vegetation Loose sapric peat Loose sapric peat Flocculent sapric peat
5 A B C D E F	2.3 ft. 3.4 4.3 5.8 7.2 11.0	5.7 ft. 9.4 8.4 10.7 + 12.0 + ---	3.4 ft. 6.0 4.1 4.9 4.8 ---	0.7 ft. 1.2 1.3 2.5 1.6 ---	20.6 % 20.0 31.8 51.0 33.3	0.3' Flocculent peat, 0.4' loose peat with undecomposed vegetation Flocculent sapric peat Flocculent sapric peat Flocculent sapric peat 0.7' flocculent peat, 0.9' loose peat

Table 3 FISH CREEK Delta Sediment Data

SAMPLE STATION	CURRENT LAKE BOTTOM	ORIGINAL LAKE BOTTOM	NEW SEDIMENT THICKNESS	COMPRESSED SEDIMENT THICKNESS	COMPRESSED AS PERCENTAGE OF ORIGINAL	DESCRIPTION OF NEW SEDIMENTS (top to bottom)
6 A	2.9 ft.	6.7 ft.	3.8 ft.	0.2 ft.	5.3 %	Flocculent sapric peat
B	3.7	8.0	4.3	0.7	16.3	Flocculent sapric peat
C	4.4	8.9	4.5	0.3	6.7	Flocculent sapric peat
D	5.2	8.6	3.4	0.3	8.8	Flocculent sapric peat
E	4.8	8.6	3.8	0.6	15.8	Loose sandy sapric peat
7 A	2.4 ft.	7.9 ft.	5.5 ft.	0.7 ft.	12.7 %	Loose sapric peat
B	2.8	9.7	6.9	0.5	7.2	Loose sapric peat
C	3.5	9.8	6.3	0.7	11.1	Loose sapric peat
D	3.1	8.6	5.5	0.8	14.5	Loose sapric peat
E	3.7	7.1	3.4	0.2	2.9	Loose sapric peat
F	3.9	9.0	5.1	0.9	17.6	Loose sapric peat
8 A	1.9 ft.	5.6 ft.	3.7 ft.	0.4 ft.	10.8 %	Loose sapric peat
B	2.4	6.9	4.5	0.4	8.8	Loose sapric peat
C	3.4	6.5	3.1	0.5	16.1	Loose sapric peat
D	3.1	6.0	2.9	0.5	17.2	Loose sapric peat
E	3.2	6.9	3.7	0.5	13.5	Loose sapric peat
F	3.5	8.4	4.9	1.0	20.4	Loose sapric peat
9 A	1.7 ft.	---	---	---		Sandy clay with some shells (old bottom?)
B	2.4	5.2 ft.	2.8 ft.	0.1 ft.	3.6 %	Flocculent sapric peat
C	2.7	4.7	2.0	0.4	20.0	" " "
D	2.4	5.1	2.7	0.3	11.1	" " "

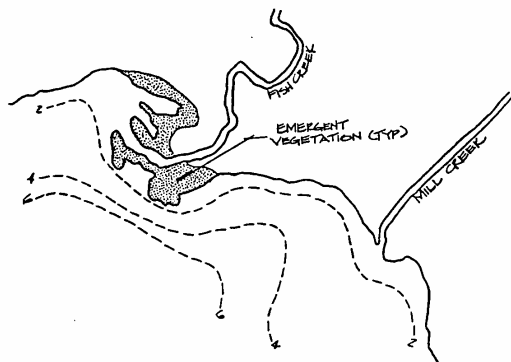
Table 3

MILL CREEK Delta Sediment Data

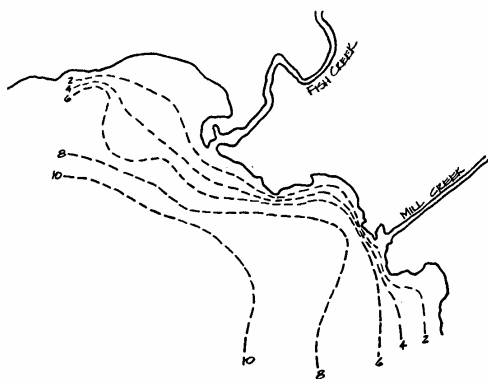
Two bathymetric maps were prepared from the sediment coring data (Figure 16). The first shows the current lake bottom as measured from each of the 46 sampling station locations. The second shows the estimated "historic" lake bottom. For the purpose of this study, we consider the "historic lake bottom to be that which occurred before lake sedimentation accelerated due to human disturbance in the watershed. A third bathymetric map was prepared for comparison purposes from the 1952 IDNR map of the lake. Three dimensional bottom maps were also prepared for illustrative purposes (Figures 17 and 18).

Comparison of the current lake bottom map with the 1952 and "historic" shows that significant filling of Upper Fish Lake has occurred. An estimated 120,400 cubic yards of new sediments have been deposited on the "historic" lake bottom within the core sampled area of Upper Fish Lake. The volume measurement based on the compressed thickness of each sample is approximately 33,000 cubic yards. The depth of the new sediments ranges from essentially 0 feet in Transect 1 where currents and wave action apparently keeps the bottom scoured to almost 8 feet (Table 3). High speed boating, a problem on some lakes, is not allowed on Fish Lake. Average depth of uncompressed sediment in the sampled area is 3.7 feet in the Fish Creek delta and 3.8 feet in the Mill Creek delta.

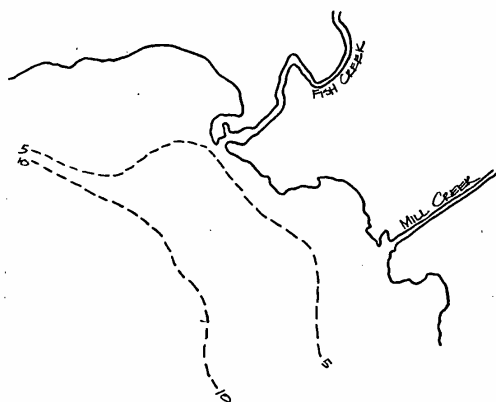
Lake in-filling has been severe at both the Fish and Mill Creek inlets though delta formation has progressed differently at each inlet. The delta formed at the Fish Creek inlet is relatively shallow and is vegetated with much more extensive stands of emergent vegetation. The Mill Creek delta is somewhat deeper but extends farther out into the lake. Submerged and floating leaved aquatic plants dominate this delta. Comparison of the shift in the location of the 6 foot contour from the "historic" to current condition shows this clearly. This difference may be the result of differences in sediment particle sized transported by each stream system.



Current Lake Bottom
(1987 Shoreline)




Historic Lake Bottom per Core Sampling
(1952 Shoreline)



1952 Topography
(From IDNR)

SCALE: 1" = 500'

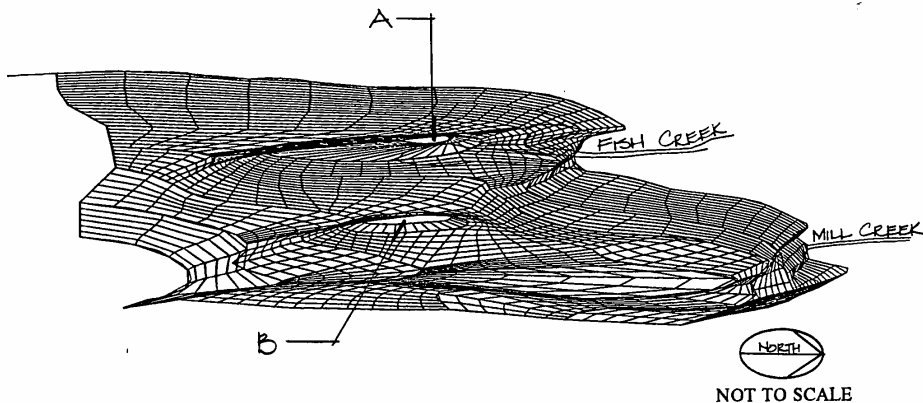




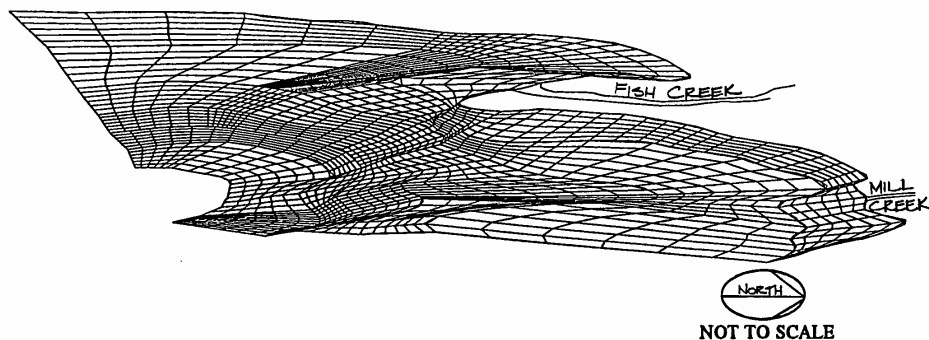
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ORIGINAL BOTTOM LOOKING WEST



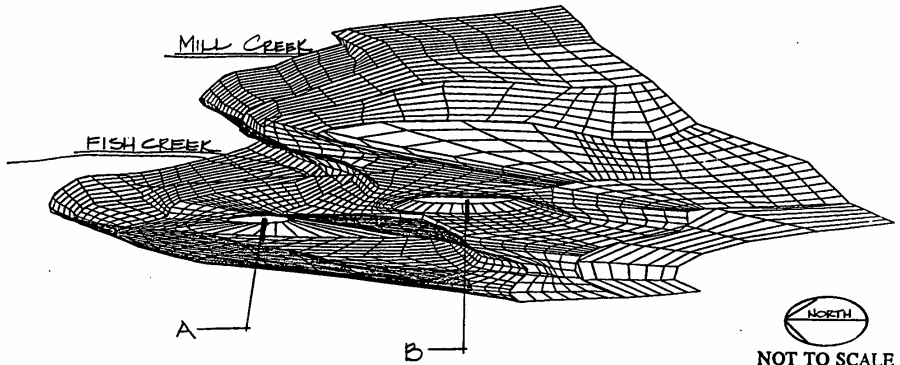
CURRENT BOTTOM LOOKING WEST



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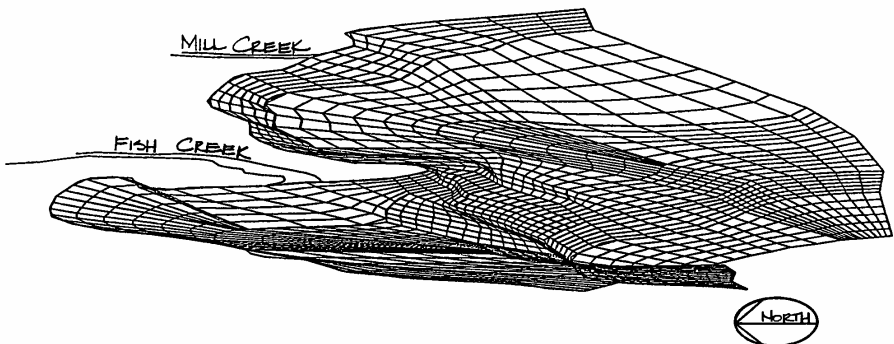
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NOT TO SCALE

ORIGINAL BOTTOM LOOKING EAST



NOT TO SCALE

CURRENT BOTTOM LOOKING EAST



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AQUATIC MACROPHYTE SURVEY

AQUATIC MACROPHYTE SURVEY

Because one of the most noticeable or visible problems in Fish Lake is the localized abundance of aquatic vegetation, a survey was made to map and identify the dominant species, and to identify areas which may require chemical control of macrophytes and those areas which should be left undisturbed. To account for the annual progression in the development of the aquatic macrophyte beds in terms of both density and species composition, two surveys were required to document the changes in size, density, and dominant species within the lake. This information makes it possible to treat problem areas more precisely and effectively.

Methods

Aquatic macrophyte surveys were made for the entire Fish Lake system on June 4, 1991 and August 1, 1991. Aquatic and wetland macrophytes are generally grouped into three classes: emergents (e.g. cattail), floating leaved (e.g. water lily), and submergents (e.g. pondweed). In the Fish Lake system, emergent plants are primarily associated with the shoreline. These stands were generally limited in size and were not mapped as the focus of this portion of the study was to identify and set management goals for macrophyte beds within the lake. Areas of the lake with very small or sparse beds of vegetation were also not identified.

The lake was cruised by small motorboat and notes were taken on the location, extent, percent cover, and composition of aquatic plant beds. Percent areal cover within a bed was estimated as a range of values to take into account variations within a bed. Single macrophyte beds which changed significantly in percent cover or species composition from one area to another were mapped as two or more contiguous beds to note this change. Species within a mapped bed were ranked according to whether they were dominant, subdominant, or minor components of the bed. Dominant species comprised a majority of the bed. Subdominants were common but not in the majority. Minor species were simply present in small numbers.

Species Composition and Areal Coverage

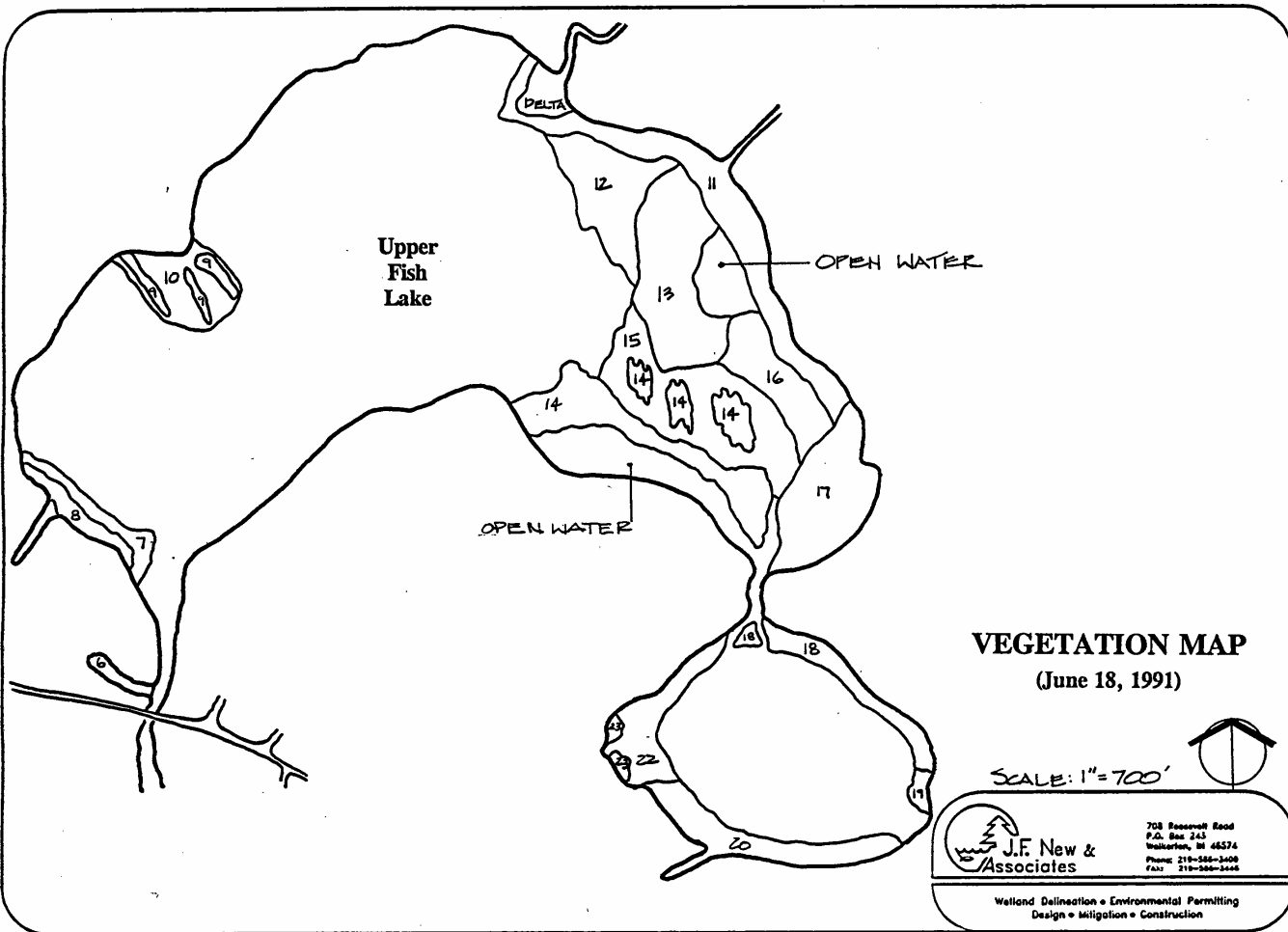
The spring macrophyte survey showed the eastern third of Upper Fish Lake was covered by extensive beds of aquatic macrophytes and filamentous algae (Figure 19). Dominants within this area included curly leaf pondweed (*Potamogeton crispus*), yellow pond lily (*Nuphar luteum*, = *advena*), filamentous algae, white water lily (*Nymphaea tuberosa*) (Table 4). The delta formed by sediment input from Fish Creek was dominated by a thick

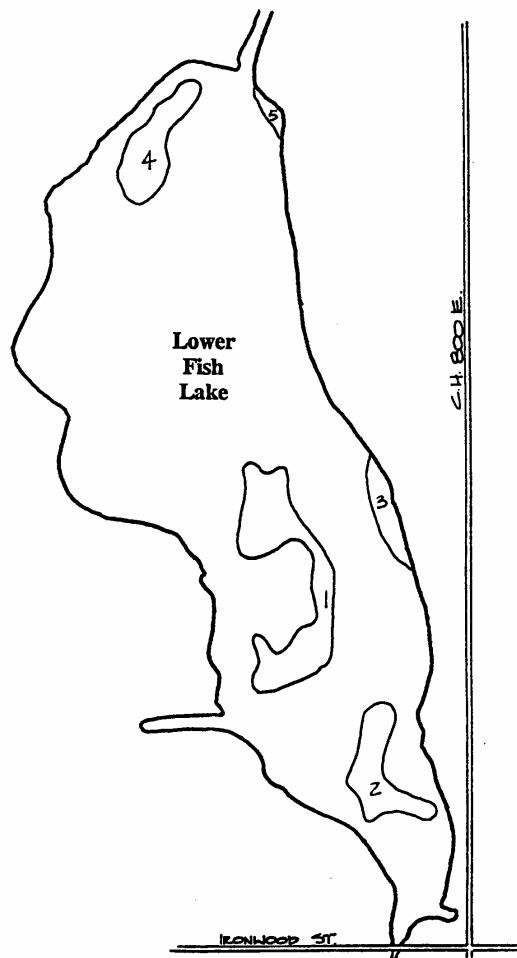
stand of purple loosestrife (*Lythrum salicaria*). Mud Lake was fringed with beds dominated by curly leaf pondweed, yellow pond lily, and white water lily. The remainder of Upper Fish Lake was relatively free of vegetation except for two areas along the west and southwest shores. Neither of these areas were very extensive or well developed at this time.

Macrophyte beds in Lower Fish Lake were quite different from those of Upper Fish Lake in terms of species composition. This is likely due to better water quality as discussed in a previous section. Milfoil (*Myrophyllum heterophyllum*, *M. spicatum*), curly leaf pondweed, and Richardson's pondweed (*Potamogeton richarsonii*) were the dominants while the large floating leaf macrophytes were either minor components of the beds or not present (Figure 20 and Table 4). These beds were, for the most part, far enough below the surface or sparse enough not to be a problem for boat traffic.

The late summer survey showed that significant changes had occurred within most of the macrophyte beds. Many of the beds in eastern Upper Fish Lake and Mud Lake had degenerated to some degree (Figure 21 and Table 5). Filamentous algae which covered extensive areas of eastern Upper Fish Lake was no longer present except as a very minor component. It was likely present only early in the season because the annual spring turnover in the lake brought excessive nutrients to the surface. Once these nutrients were removed from the water column, the algae bloom disappeared. A species not seen in the spring survey, Chara (*Chara spp.*) became dominant over a large area. Chara is a communal macroalgae and not a true plant. Other dominants included yellow pond lily, white water lily, and the two pondweeds. The two beds on the western side of the lake enlarged somewhat and became more dense.

Lower Fish Lake also changed significantly. Beds at the north end of the lake expanded greatly (Figure 22 and Table 5). Dominant vegetation included eel grass (*Vallisneria americana*), curly leaf pondweed, and chara. Filamentous algae was also present. Elsewhere in Lower Fish Lake, beds were dominated variously by white water lily, chara, milfoil, and coontail (*Ceratophyllum demersum*). Upper Fish Lake tended to be dominated by floating leaf macrophytes while submersed aquatic macrophytes dominated Lower Fish Lake.



**VEGETATION MAP**

(June 18, 1991)

SCALE: 1" = 700'

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MACROPHYTE SPECIES and COVERAGE

Sample Date: June 18, 1991

Status: D = Dominant or Co-dominant
 S = Subdominant
 M = Minor

MAP AREA	PERCENT COVERAGE	SPECIES STATUS	LATIN NAME	COMMON NAME
1	50 to 80%	D M M M M	Myriophyllum heterophyllum Myriophyllum spicatum Potamogeton crispus Potamogeton richardsonii Vallisneria americana	Two-leaf water milfoil Eurasian water milfoil Curly pondweed Richardson's pondweed Wild celery
2	10 to 20%	D M M M M	Myriophyllum heterophyllum Myriophyllum spicatum Potamogeton crispus Potamogeton richardsonii Vallisneria americana	Two-leaf water milfoil Eurasian water milfoil Curly pondweed Richardson's pondweed Wild celery
3	5 to 10%	D	Myriophyllum heterophyllum	Two-leaf water milfoil
4	30 to 50%	D D M	Myriophyllum spp. Potamogeton crispus Potamogeton richardsonii	Water milfoil Curly pondweed Richardson's pondweed
5	10 to 20%	D S S M M	Potamogeton richardsonii Myriophyllum spp. Potamogeton crispus Lemna spp. Nymphaea odorata	Richardson's pondweed Water milfoil Curly pondweed Duckweed White water lily
6	50 to 80%	D	Potamogeton crispus	Curly pondweed
7	20 to 60%	D M M	Myriophyllum spp. Ceratophyllum demersum Potamogeton crispus	Water milfoil Coontail Curly pondweed
8	30 to 50%	D	Nuphar luteum	Yellow cow lily
9	80 to 100%	D D M M	Myriophyllum spp. Potamogeton crispus Chara spp. Potamogeton pectinatus	Water milfoil Curly pondweed Chara, Stonewort Sago pondweed

Table 4

Macrophyte Species and Coverage 6/18/91

MAP AREA	PERCENT COVERAGE	SPECIES STATUS	LATIN NAME	COMMON NAME
10	10 to 20%	D D D M M M	Myriophyllum heterophyllum Myriophyllum spicatum Potamogeton crispus Chara spp. Potamogeton pectinatus Potamogeton richardsonii	Two-leaf water milfoil Eurasian water milfoil Curly pondweed Chara, Stonewort Sago pondweed Richardson's pondweed
11	80 to 90%	D D D M M M M	Filamentous algae Nuphar luteum Potamogeton crispus Ceratophyllum demersum Lemna minor Myriophyllum spp. Wolffia spp.	Filamentous algae Yellow cow lily Curly pondweed Coontail Duckweed Water milfoil Water meal
12	10 to 15%	D D D	Filamentous algae Myriophyllum spp. Potamogeton crispus	Filamentous algae Water milfoil Curly pondweed
13	50 to 90%	D D M M M M	Filamentous algae Potamogeton crispus Ceratophyllum demersum Lemna minor Myriophyllum spp. Wolffia spp.	Filamentous algae Curly pondweed Coontail Duckweed Water milfoil Water meal
14	40 to 80%	D D M M M	Filamentous algae Potamogeton crispus Lemna minor Myriophyllum spp. Wolffia spp.	Filamentous algae Curly pondweed Duckweed Water milfoil Water meal
15	0 to 20%	D D D	Filamentous algae Myriophyllum spp. Potamogeton crispus	Filamentous algae Water milfoil Curly pondweed
16	50 to 90%	D D S M	Filamentous algae Potamogeton crispus Nuphar luteum Myriophyllum spp.	Filamentous algae Curly pondweed Yellow cow lily Water milfoil

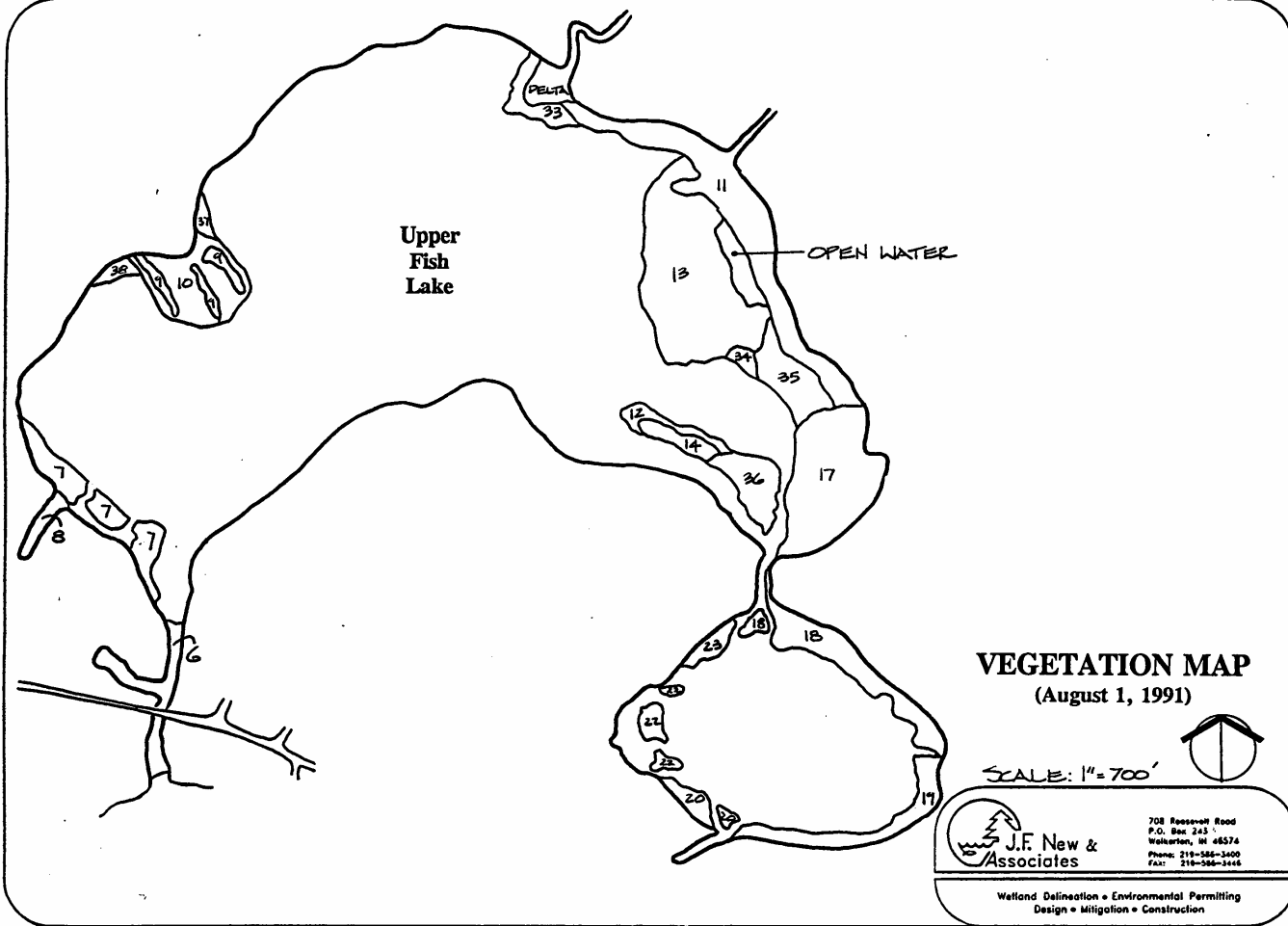
Table 4

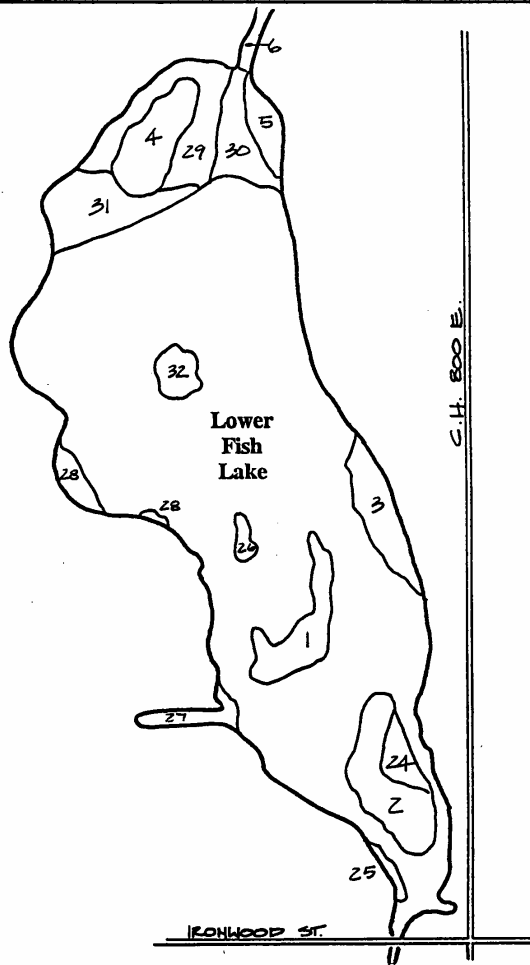
Macrophyte Species and Coverage 6/18/91

MAP AREA	PERCENT COVERAGE	SPECIES STATUS	LATIN NAME	COMMON NAME
17	60 to 90%	D D S S	Nuphar luteum Nymphaea odorata Filamentous algae Pontedaria cordata	Yellow cow lily White water lily Filamentous algae Pickerel weed
18	70 to 100%	D S S S M M M M	Nuphar luteum Filamentous algae Nymphaea odorata Potamogeton crispus Ceratophyllum demersum Myriophyllum spp. Pontedaria cordata Potamogeton richardsonii Vallisneria americana	Yellow cow lily Filamentous algae White water lily Curly pondweed Coontail Water milfoil Pickerel weed Richardson's pondweed Wild celery
19	80 to 100%	D D M	Nuphar luteum Nymphaea odorata Filamentous algae	Yellow cow lily White water lily Filamentous algae
20	60 to 80%	D M	Nuphar luteum Myriophyllum heterophyllum	Yellow cow lily Two-leaf water milfoil
21	(This number was not used on the map)			
22	10 to 30%	D M M	Potamogeton crispus Filamentous algae Myriophyllum heterophyllum	Curly pondweed Filamentous algae Two-leaf water milfoil
23	70 to 90%	D M	Nuphar luteum Myriophyllum heterophyllum	Yellow cow lily Two-leaf water milfoil

Table 4

Macrophyte Species and Coverage 6/18/91





VEGETATION MAP (August 1, 1991)

SCALE: 1" = 700'



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MACROPHYTE SPECIES and COVERAGE

Sample Date: August 1, 1991

Status: D = Dominant or Co-dominant
S = Subdominant
M = Minor

MAP AREA	PERCENT COVERAGE	SPECIES STATUS	LATIN NAME	COMMON NAME
1	20 to 40%	D	Myriophyllum heterophyllum	Two-leaf water milfoil
		D	Vallisneria americana	Wild celery
		M	Potamogeton richardsonii	Richardson's pondweed
2	20 to 50%	D	Chara spp.	Chara, Stonewort
		S	Potamogeton crispus	Curly pondweed
		S	Potamogeton richardsonii	Richardson's pondweed
		S	Vallisneria americana	Wild celery
		S	Myriophyllum spicatum	Eurasian water milfoil
3	5 to 10%	D	Potamogeton crispus	Curly pondweed
		M	Ceratophyllum demersum	Coontail
		M	Myriophyllum heterophyllum	Two-leaf water milfoil
		M	Vallisneria americana	Wild celery
4	80 to 100%	D	Ceratophyllum demersum	Coontail
		D	Chara spp.	Chara, Stonewort
		D	Myriophyllum spp.	Water milfoil
		D	Potamogeton crispus	Curly pondweed
		D	Vallisneria americana	Wild celery
5	60 to 80%	D	Chara spp.	Chara, Stonewort
		D	Vallisneria americana	Wild celery
		M	Ceratophyllum demersum	Coontail
		M	Filamentous algae	
		M	Myriophyllum heterophyllum	Two-leaf water milfoil

Table 5

Macrophyte Species and Coverage 8/1/91

MAP AREA	PERCENT COVERAGE	SPECIES STATUS	LATIN NAME	COMMON NAME
6	0 to 90%	D D	Potamogeton crispus Vallisneria americana	Curly pondweed Wild celery
7	20 to 100%	D S M M M	Nymphaea odorata Chara spp. Ceratophyllum demersum Nuphar luteum Vallisneria americana	White water lily Chara, Stonewort Coontail Yellow cow lily Wild celery
8	100%	D	Lemna minor	Duckweed
9	80 to 100%	D S S S	Chara spp. Myriophyllum spp. Potamogeton crispus Vallisneria americana	Chara, Stonewort Water milfoil Curly pondweed Wild celery
10	30 to 60%	D S S S	Chara spp. Myriophyllum spp. Potamogeton crispus Vallisneria americana	Chara, Stonewort Water milfoil Curly pondweed Wild celery
11	80 to 90%	D D D M M M M	Filamentous algae Nuphar luteum Potamogeton crispus Ceratophyllum demersum Lemna minor Myriophyllum spp. Wolffia spp.	Filamentous algae Yellow cow lily Curly pondweed Coontail Duckweed Water milfoil Water meal
12	20 to 50% 6" to 2' down	D D M	Ceratophyllum demersum Myriophyllum spp. Vallisneria americana	Coontail Water milfoil Wild celery

Table 5

Macrophyte Species and Coverage 8/1/91

MAP AREA	PERCENT COVERAGE	SPECIES STATUS	LATIN NAME	COMMON NAME
13	90 to 100%	D M M M M M	Chara spp. Ceratophyllum demersum Myriophyllum spp. Potamogeton crispus Potamogeton richardsonii Nymphaea odorata	Chara, Stonewort Coontail Water milfoil Curly pondweed Richardson's pondweed White water lily
14	50 to 90%	D D D M	Ceratophyllum demersum Chara spp. Myriophyllum spp. Vallisneria americana	Coontail Chara, Stonewort Water milfoil Wild celery
15, 16	(These numbers are not used on the map)			
17	90 to 100%	D D M M M M	Nuphar luteum Nymphaea odorata Lythrum salicaria Myriophyllum spp. Peltandra virginica Potamogeton richardsonii	Yellow cow lily White water lily Purple loosestrife Water milfoil Arrow arum Richardson's pondweed
18	70 to 90%	D M M M	Nuphar luteum Nymphaea odorata Myriophyllum spicatum Potamogeton richardsonii	Yellow cow lily White water lily Eurasian water milfoil Richardson's pondweed
19	80 to 100%	D D	Nuphar luteum Nymphaea odorata	Yellow cow lily White water lily
20	80 to 100%	D D M	Nuphar luteum Nymphaea odorata Myriophyllum spp.	Yellow cow lily White water lily Water milfoil
21	(This number is not used on the map)			

Table 5

Macrophyte Species and Coverage 8/1/91

MAP AREA	PERCENT COVERAGE	SPECIES STATUS	LATIN NAME	COMMON NAME
22	70 to 100%	D D M M	Nuphar luteum Nymphaea odorata Ceratophyllum demersum Myriophyllum spp.	Yellow cow lily White water lily Coontail Water milfoil
23	50 to 70%	D S	Nymphaea odorata Nuphar luteum	White water lily Yellow cow lily
24	20 to 90%	D D M	Myriophyllum heterophyllum Myriophyllum spicatum Potamogeton crispus	Two-leaf water milfoil Eurasian water milfoil Curly pondweed
25	80 to 100%	D D	Chara spp. Myriophyllum heterophyllum	Chara, Stonewort Two-leaf water milfoil
26	20 to 40%	D D	Ceratophyllum demersum Myriophyllum heterophyllum	Coontail Two-leaf water milfoil
27	70 to 100%	D S S	Chara spp. Myriophyllum heterophyllum Potamogeton crispus	Chara, Stonewort Two-leaf water milfoil Curly pondweed
28	70 to 100%	D M M M M	Nuphar luteum Myriophyllum heterophyllum Myriophyllum spicatum Potamogeton crispus Vallisneria americana	Yellow cow lily Two-leaf water milfoil Eurasian water milfoil Curly pondweed Wild celery
29	10 to 30%	D D D D D	Ceratophyllum demersum Chara spp. Myriophyllum spp. Potamogeton crispus Vallisneria americana	Coontail Chara, Stonewort Water milfoil Curly pondweed Wild celery
30	50 to 70%	D	Vallisneria americana	Wild celery

Table 5

Macrophyte Species and Coverage 8/1/91

MAP AREA	PERCENT COVERAGE	SPECIES STATUS	LATIN NAME	COMMON NAME
31	50 to 70%	D S M	Vallisneria americana Myriophyllum heterophyllum Ceratophyllum demersum	Wild celery Two-leaf water milfoil Coontail
32	100%	D M	Nymphaea odorata Potamogeton richardsonii	White water lily Richardson's pondweed
33	50 to 70%	D M M M	Nuphar luteum Ceratophyllum demersum Myriophyllum spp. Vallisneria americana	Yellow cow lily Coontail Water milfoil Wild celery
34	50 to 60%	D D D N	Ceratophyllum demersum Myriophyllum spp. Nymphaea odorata Nuphar luteum	Coontail Water milfoil White water lily Yellow cow lily
35	90 to 100%	D	Nymphaea odorata	White water lily
36	100%	D S	Nuphar luteum Nymphaea odorata	Yellow cow lily White water lily
37	70 to 100%	D S S	Chara spp. Potamogeton crispus Vallisneria americana	Chara, Stonewort Curly pondweed Wild celery
38	50 to 80%	D M M M	Nymphaea odorata Chara spp. Myriophyllum spp. Potamogeton crispus	White water lily Chara, Stonewort Water milfoil Curly pondweed

Table 5

Macrophyte Species and Coverage 8/1/91

Changes Since Previous Work

In August 1984 Aquatic Control, Inc. (Johnson 1984) carried out a macrophyte survey of the Fish Lake system and produced a generalized location map of the vegetation in the lake. It was our intent to compare this map with those produced in this study in an attempt to document changes in species composition and aerial extent of the macrophyte beds. While the Aquatic Control, Inc. report was located, the accompanying vegetation map has apparently been lost. Aquatic Control, Inc. was contacted but did not have a copy on file.

The body of that report does, however, list separately the major and minor species present in each of the three Fish Lake basins. We can therefore make some gross comparisons on a basin-by-basin basis with this study's August data. It should be cautioned that Aquatic Control's designation of species as "major" or "minor" and this studies dominance designations are subjective. In 1984, major species in Mud Lake included coontail, spatterdock, white waterlily, chara, and filamentous algae. Pondweeds and milfoil were minor bed components. This species assemblage is very similar to that found in this study in which coontail, spatterdock, and white waterlily were found to be dominant while the milfoils and pondweeds were again minor components. Only chara and filamentous algae, noted as major species in 1984, were missing or present in such a low density that they were not noted in 1991.

In 1984, Upper Fish lake was dominated by milfoil, eel grass, pondweeds, slender niad (*Najas flexilis*), white waterlily, spatterdock, chara, and filamentous algae. Again, the same suite of species was dominant with the exception of slender niad which was not reported in this survey. As slender niad superficially resembles chara and often grows in the same beds, it may have been overlooked in this study. Eel grass, chara, slender niad, white waterlily, and spatterdock dominated Lower Fish lake in 1984 while 1991 was characterized by eel grass, chara, coontail, milfoil, and white waterlily. Spatterdock was only present in very small numbers. The addition of coontail and milfoil in this study is a significant change as they were not even mentioned as a minor species in 1984 but covered extensive areas in 1991. Milfoils, and in particular eurasian milfoil can be difficult to control.

While it was not possible to compare maps to contrast the aerial extent of the 1984 and 1991 macrophyte beds, interviews with lake residents seem to indicate that vegetation in the lake was not as big a problem in 1991 as it has been in previous years. This could be the result of several factors. Because of record drought conditions in 1991 may have reduced the sediment and nutrient inputs to the lake aquatic plant growth might be expected to decrease. However, Richard Soper, a licensed herbicide applicator many

years experience on Fish Lake and many other lakes in northern Indiana and southern Michigan, in an interview state that contrary to what might be expected in a drought year, the vegetation problems on many lakes he was working on in 1991 were not diminished. Although reduced sediment and nutrient inputs from agricultural land could be reasonably expected, he felt that aquatic vegetation growth was perhaps maintained by a corresponding increase in water clarity and sunlight penetration. The noticeable reduction in aquatic vegetation in Fish Lake *may* be a result of the cessation of pumping from the Cranberry Bog and the associated decrease in sediment and nutrient loading. Though the lake system has not been treated since 1990 the vegetation reduction may also be a result of "carryover" effect from years of herbicide applications. If chemical control is eliminated and nutrient inputs are not controlled large-scale macrophyte problems will probably return.

Purple Loosestrife

Purple loosestrife (*Lythrum salicaria*) has been reserved as a separate entity in this report. It is a highly invasive alien species which has not been addressed as a wetland problem in previous reports. Although it is not known when purple loosestrife appeared in the Fish Lake watershed, it was observed in the early 1970's (personal observation by Jim New). By the early 1980's it was widely distributed and by 1990 was a dominant plant in the watershed. It is the dominant species in many of the marshes along Fish Creek and on the higher portions of the Fish Creek delta. It is a very aggressive invader with very limited wildlife value.

LAKE MANAGEMENT AND RESTORATION ALTERNATIVES

LAKE MANAGEMENT AND RESTORATION ALTERNATIVES

Specific lake management alternatives are discussed in some detail in the EPA's *The Lake and Reservoir Restoration Guidance Manual* (Moore and Thornton 1988). The draft feasibility report (Turnbell 1988) also provides a discussion of lake management alternatives as they apply to Fish Lake. This report will therefore only provide a brief discussion of selected management alternatives and recommends the reader to the above mentioned documents for more detailed discussions.

Macrophyte Control

1. Harvesting.

Aquatic weeds can be mechanically harvested and removed from the lake for disposal. One advantages of this method is that plant material is removed from the lake. This method is also very site selective. However harvesting must be done annually and in some cases several times in a year. Fragmentation of plants can spread infestation in some cases. This is particularly true for milfoil. Additionally, control is effective only to limited depths. Turnbell (1988) estimated the costs of contracting this work out at \$50,000 to \$125,000 a year. Long-term costs could be reduced, however, if the Lake Association purchased its own harvester. We do not recommend this alternative based on high costs, limited effectiveness, and plant fragmentation problems.

2. Lake Drawdown.

Lake drawdown to consolidate and oxidize sediments can be an effective macrophyte control method in many situations. Fish Lake, however, does not have a water control structure suitable for this management alternative.

3. Biological Control.

Biological control uses pathogenic or herbivorous organisms to achieve lasting control of nuisance plants. Currently, however, none are available in Indiana. Perhaps the most commonly used biological control in lakes is the grass carp. It has certain limitations, however, and its use is prohibited in Indiana. Several biological controls of purple loosestrife are expected to be available within the next few years in Indiana and the Lake Association is encouraged to keep appraised of their potential availability by contacting the IDNR Division of Entomology.

4. Chemical Control.

Herbicides can effectively be used to control nuisance weed growth to meet short-term management goals. Chemical control can be exercised selectively in many cases with the use of herbicides targeted to specific species. Control can also be limited to specific parts of the lake. However nontarget species are often affected by the herbicides used. Another drawback is that dead plant material is left in place in the lake where it decays reducing oxygen levels and releasing nutrients into the water column. Chemical control of Mud, Upper Fish, and Lower Fish Lakes is estimated to be \$31,000 a year. This alternative is recommended as cost effective and sufficiently selective.

Nutrient and Sediment Control

1. Dredging.

Sediment removal has the dual effect of reducing (deepening) the substrate available for macrophyte growth and removing nutrients. It can be very effective in long-term macrophyte control if sediment inputs are also controlled. Large scale sediment removal costs, however, can be very high. Figured at a cost of \$5.00 per yard on the volume of dewatered sediment, approximately 33,000 cubic yards, hydraulic dredging of the core sampled area would cost about \$165,000. Simply removing the accumulated sediment would do nothing to protect the lake from future sediment accumulation. Because of the high cost of sediment removal and potential permitting problems, we do not recommend this alternative.

2. Phosphorus Inactivation.

The chemical inactivation of phosphorus has been proven to be highly effective in some lakes. Alum is the most commonly used agent. It combines with the phosphorus which is then precipitated out of the water column where it is unavailable for plant use. Phosphorus inactivation is not appropriate for Fish Lake at this time because internal loading of phosphorus is only about 12% (Turnbell 1988) and external sources have not been controlled. The draft Turnbell report (1988) estimated that the cost of a single alum treatment to be \$100,000.

3. Wetland Development.

The development of wetlands on lake tributaries can be a very effective method of improving the quality of water entering a lake system. Wetlands

are well known for their ability to remove nutrients from the water column and trap sediments. Wetland development, however, requires existing wetlands into which water can be diverted or detained. This usually requires the construction of water control structures. Alternatively, water can be diverted or detained in upland or drained wetland areas effectively creating or restoring wetland acreage. In the case of Fish Lake, however, suitable areas for wetland development do not appear to exist. In addition, several protected high quality fens exist above Fish Lake which would make obtaining permits for water control structures difficult if not impossible. We therefore do not recommend this alternative.

4. Sediment Traps.

Sedimentation basins can be effective in controlling sediment and phosphorus loads. Sediment traps work by slowing the flow of water thereby allowing particulate matter (and thus phosphorus) to settle out of the water column. One advantage to this alternative is that it can be done in the lake itself without impacting upstream wetlands. A disadvantage is that the basins will have to be cleaned periodically as they fill with sediments and become less efficient. The costs to develop a sediment basin in the Fish and Mill Creek deltas are estimated to be \$65,000 for both. This alternative is recommended as being more feasible than alternatives 1, 2 and 3 and more cost effective than alternative 1 in controlling sediments and nutrients in the Fish Lake system.

LAKE AND WATERSHED MANAGEMENT PLAN

LAKE AND WATERSHED MANAGEMENT PLAN

The following recommended management alternatives are presented in order of long term importance to the lake. Implementation of these alternatives may, however, follow a different order based on the Association's ability to obtain funding and/or carry them out. In addition, some alternatives may take years to implement while others can be carried out rather quickly.

- Priorities:
- 1 Watershed Land Treatment
 - 2 Sediment/Nutrient Basins
 - 3 Aquatic Vegetation Management
 - 4 Other Treatments

Watershed Land Treatment

Land treatment in the watershed should reflect the goals of the "T by 2000" program which are:

- by the year 2000, to reduce erosion on each acre of land to its-tolerable limit or T (the maximum level at which soil loss can occur without impairing crop productivity);
- by the year 2000, to control all off-site sedimentation using the best practical technology.

Although the Fish Lake Property Owners Association cannot mandate farming methods and enrollment in soil conservation programs, the Association should work closely with the LaPorte County Soil and Water Conservation District and Tri-County Water Quality Project to see that the T by 2000 goals are achieved or exceeded within the Fish Lake watershed. The importance of continued improvement of land use practices in the watershed cannot be overstated. Working with the appropriate government agencies to encourage landowners to take advantage of appropriate programs must be the keystone of any successful Fish Lake management plan.

While the "hotspots" discussed previously (page 9) represent only a small percentage of the total watershed which could benefit from land treatment and cost-share programs, a high degree of soil protection could be achieved if these areas were enrolled in the 10-year Conservation Reserve Program. Control of erosion from non- highly erodible lands, however, should not be ignored as these lands make up the majority of the Fish Lake

watershed. Specific soil conservation and water quality enhancement practices and programs are discussed in Appendix A.

Construction of Sediment Traps/Nutrient Filters

Need. A certain level of soil loss is unavoidable even if approved conservation plans are permanently implemented on all highly erodible land. The definition of a tolerable soil loss is based on a sustainable rate of soil loss without a reduction in crop productivity. For instance, the tolerable soil loss for Chelsea fine sand and Tracy sandy loam, predominant soil types in the Fish Lake watershed, is 5 tons per acre per year. Historically Fish Creek and Mill Creek were naturally protected by large areas of level, densely vegetated hydric soils such as Adrian muck and Houghton muck (T=2 tons per acre per year). Drainage ditches in the muck areas have decreased retention time and increased stream flows. As purple loosestrife continues to invade the watershed, hydric soils are losing protective vegetation such as cattails and sedges.

A sediment model of Fish Creek (Crisman 1990) estimated the sediment transported in an "annual" storm event of 2.4 inches in a 24-hour period. The results indicate that the modeled rain event would deposit 744 tons of sediment at the mouth of Fish Creek; of this, 55 tons were attributed to the Cranberry Bog watershed. With the cessation of peat mining (removing that subwatershed), the annual storm event would deposit about 689 tons at the mouth of Fish Creek under current agricultural practices. Implementation of no-till farming on highly erodible soil would reduce sediment loading to Fish Creek by 66%, to 221 tons. It is important to keep in mind that this figure represents the deposit from Fish Creek alone, from a single 24-hour storm event.

Given that sediment and nutrient runoff can be decreased but not eliminated through watershed management, the development of some sort of sediment traps/nutrient filters should be considered for the Fish Creek and Mill Creek. Crisman (1990) recommended that wetlands be constructed near the mouths of both the Fish Creek and Mill Creek inlets, while leaving the developing delta wetlands intact to take advantage of their role in nutrient and sediment retention. As discussed previously, however, an investigation of lower Fish and Mill Creeks revealed that suitable sites for wetland development do not exist for a number of reasons. We therefore suggest a modification of Crisman's recommendation.

The construction of sedimentation basins at the mouths of both Fish and Mill Creeks would allow the collection and removal of influent sediments and associated phosphorus while leaving intact the majority of the vegetated deltas. Capturing sediment and

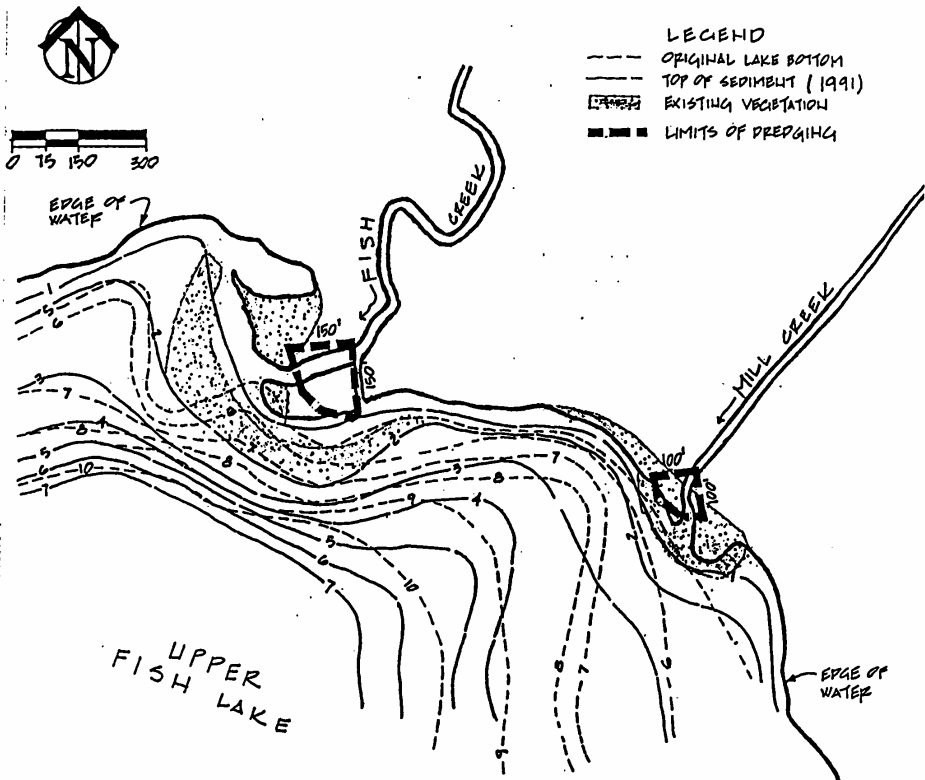
nutrients at the trap site will greatly reduce sediment and phosphorus loading and slow the continued buildup of "delta" areas in Upper Fish Lake.

Because the mean hydraulic residence time for the Fish Lake system is about 130 days and internal phosphorus loading from lake sediments is only about 12% (Crisman 1990), improvements in the quality of influent water has the potential to produce noticeable improvements in the lake. The construction of sediment basins will treat Fish Lake's immediate short term problems while long term watershed management addresses the causes or sources of the lake's problems. The effectiveness of watershed management will directly affect the efficiency of the basins and their maintenance schedule. The construction of sedimentation basins should not be considered an alternative to watershed management but as an accompaniment.


Sediment dredging sites. Fairly extensive sediment deltas have developed at the inlets of Fish Creek and Mill Creek in Upper Fish Lake. These deltas are obvious targets for any dredging program designed to remove sediments, and thus nutrients, from the lake. Simply removing these vegetated deltas would be only a short term solution for one of the lake's more visible problems and is not recommended. If the entire deltas were removed, new sediments and nutrients would be carried into the lake unchecked. The sediment and nutrient removing qualities of the developing delta wetlands should be maintained.

It is therefore recommended that the deltas be dredged in a limited fashion to create sediment traps. The center of each delta should be hydraulically dredged, and the outer perimeter of the delta left intact (Figures 23 and 24). Water will slow as it enters the sedimentation basins, dropping much of its sediment load. The water will then flow through the vegetated outer perimeter of the delta losing more of its suspended particulate matter and nutrients.

The Fish Creek sediment delta has advanced approximately 300 feet into Upper Fish Lake while the Mill Creek delta has migrated about 100 feet into the lake. The proposed sediment basins should slow or prevent further significant advancement of the deltas into the lake.



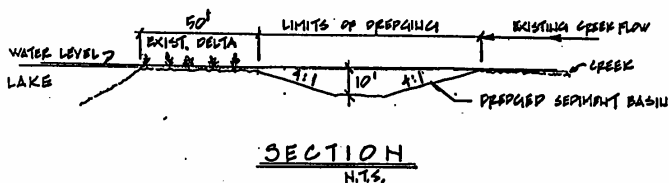
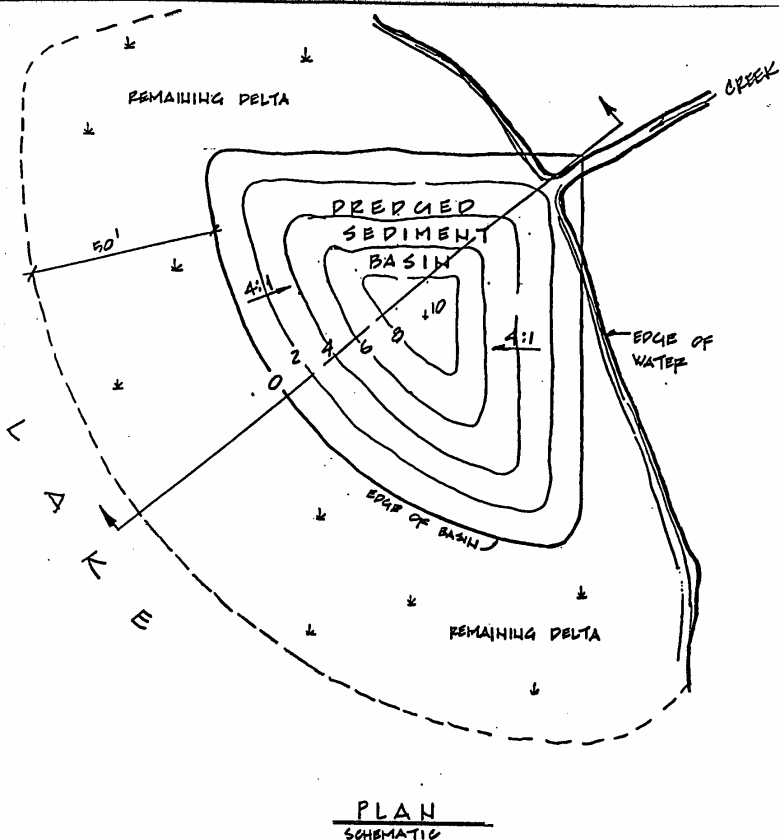
SEDIMENT BASIN LOCATIONS



**J.F. New &
Associates**

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Waukegan, IL 60074
Phone: 815-465-3400
Fax: 815-465-3448

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TYPICAL SEDIMENT BASIN



J.F. New & Associates

708 E. 2nd St.
P.O. Box 243
Waukegan, IL 60087
Phone: 815-866-3400
Fax: 815-866-3408

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FIGURE 24

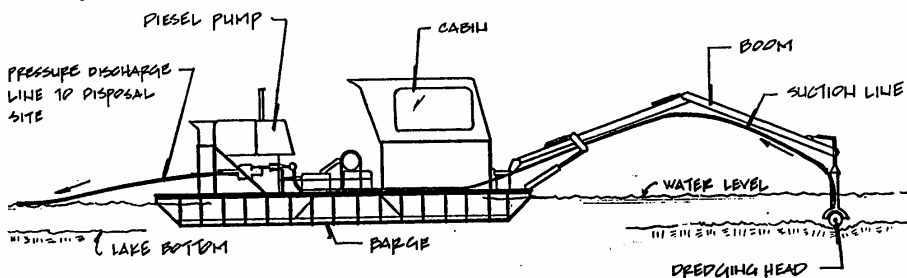
Hydraulic dredging. The sediment control basins in the deltas should be constructed by hydraulic dredging. Access to these areas by dragline, the disposal of sidecast material and the fragility of the entire area make other recommendations impractical. A hydraulic dredge consists of a barge, a roto tiller mounted on the end of a boom, and a pump (Figure 25). The roto tiller suspends sediment under water and the pump removes the water and suspended sediment and discharges it through a pipe to a disposal area. The sediment and water slurry which the dredge discharges consists of about twenty percent sediment and eighty percent water. At the dredging disposal site the sediment separates from the slurry and the water is allowed to return to the lake. The traps should be monitored periodically and cleaned by hydraulic dredging when approximately 50% full.

Disposal areas. Sediment is removed from the discharge slurry by allowing it to settle in a series of constructed basins (Figure 26). A single large basin may be used, however, a series of basins or cells separated by filter fabric is more efficient. Once the sediment is dry the site may be restored and returned to agricultural, recreational, or other uses.

At least 2 acres will be required for a disposal area. Four areas have been identified within one mile of the dredging sites (Figure 27). Upper Fish Lake is bordered in the northwest by wetland. It is illegal to discharge dredging slurry into wetlands, therefore targeted disposal areas must be uplands. The soils at these sites are predominately sandy loams or loamy sands (Figure 28).

Disposal areas 1 and 2 are nearest the dredging sites. Area 1 is predominantly loamy sand with a grass cover and a few small trees. Area 2 is predominantly sandy loam with grass and scrub/shrub cover. The topography of both areas is relatively flat and is suitable for development as a disposal site. Areas 1 and 2 are currently being used as a private recreational facility.

Area 3 appears to be close to the dredging site, however, the railroad tracks may be an obstacle for the dredging discharge piping route. If a culvert under the railroad west of the Fish Creek culvert cannot be located then the pipe would have to run up Fish Creek, under 200 South and the railroad, and then east to the disposal site. The soils are predominantly sands and sandy loams and the site is used as cropland. The slopes on Area 3 present a challenge for the construction of a disposal site however the area could be used.



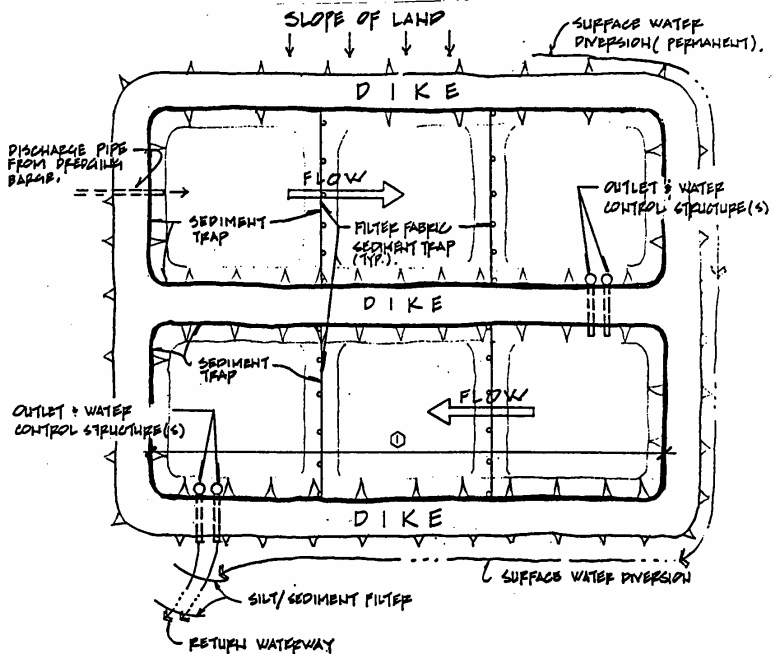
HYDRAULIC DREDGE



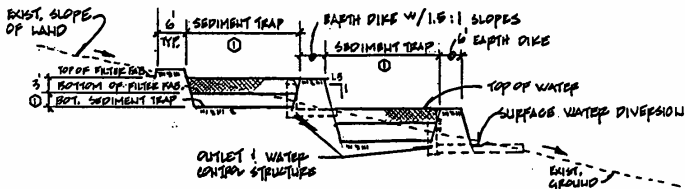
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Waterloo, MI 48674
Phone: 519-348-3400
FAX: 519-348-3448

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SEDIMENT DISPOSAL AREA PLAN
SCHEMATIC



SECTION
N.T.S.

① DISPOSAL SITE DIMENSIONS: DETERMINED BY VOLUME OF SEDIMENTING REQUIRED.

DISPOSAL SITE PLAN



708 Roosevelt Road
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Waterton, IN 45774
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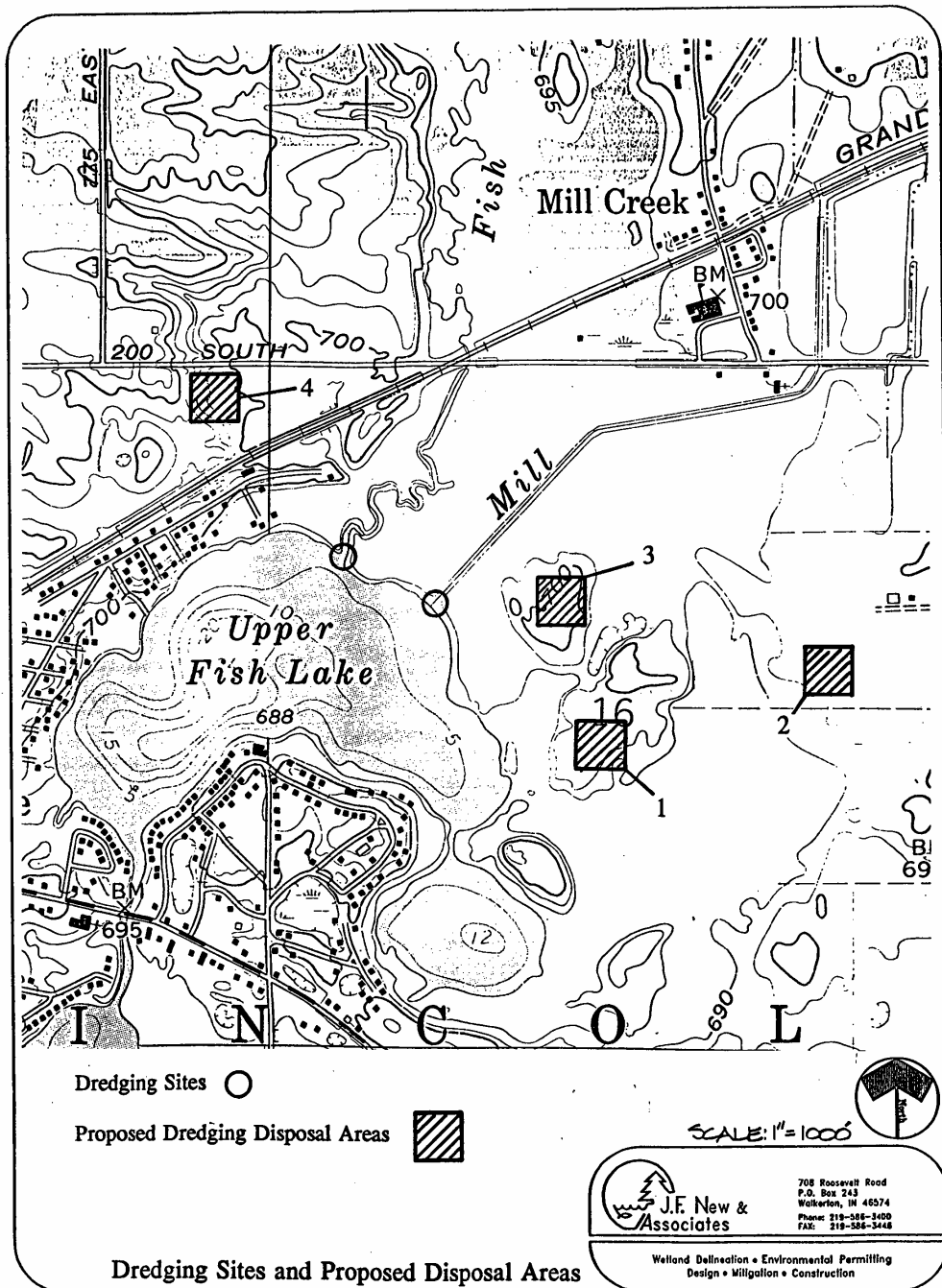


FIGURE 27

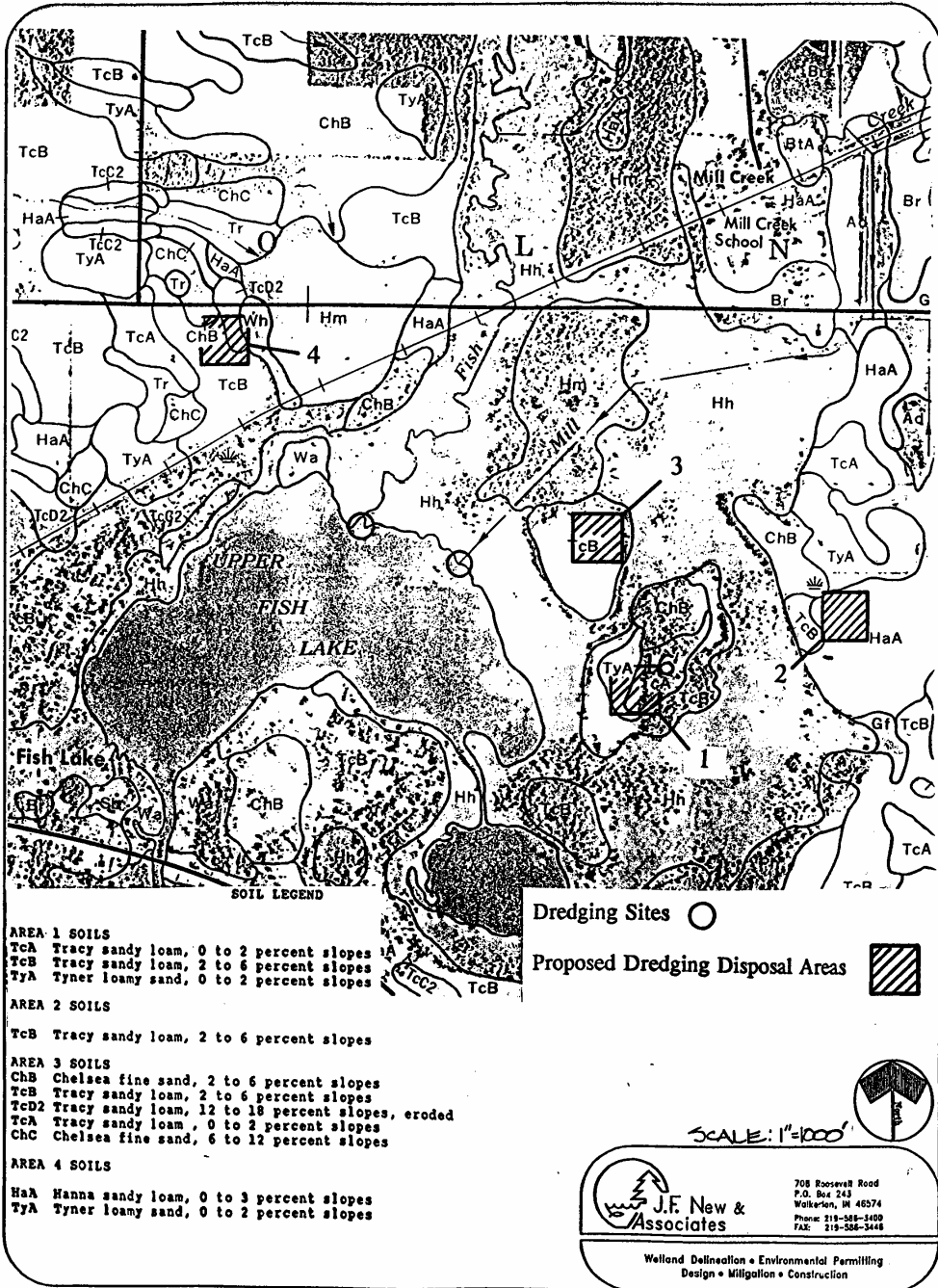


FIGURE 28

Area 4 is furthest from the dredging sites, however it appears to be accessible from both the road and dredging site. The soils are predominantly sandy loam and the area is currently in row crops. The site may actually be improved for agriculture by the addition of large amounts of nutrient rich organic matter to the sandy soils. The topography has no limitations for the construction of a disposal site. The cost of pumping slurry to this area may be higher than for Areas 1 and 2 if an additional in-line pump is required.

A property owner south of Mud Lake has expressed interest in receiving the dredged sediment on his property, and the property does have an area of Tracy sandy loam with 2 to 6% slopes (TcB). This property is just over one mile from the dredging site, along the eastern shoreline of Mud Lake. The cost of pumping slurry to this disposal area may be higher than for Areas 1 and 2, however this may be offset by a reduction in land acquisition costs.

Project cost estimates. There is a saying among old engineers and contractors, and it says that you don't have a cost until you have a cost. Construction costs may be estimated conservatively, however, land acquisition costs are greatly variable. Sometimes it is necessary to increase construction costs to make use of less expensive land. The scope of any project may be adjusted to remain within a budget amount.

The following project cost estimates are presented as guidelines for the Lake Association:

1.	Hydraulically dredge Fish Creek sediment delta 5000 cubic yards	\$ 25,000.00
2.	Hydraulically dredge Mill Creek sediment delta 2000 cubic yards	10,000.00
3.	Preparation of sediment basins at the disposal site	10,000.00
4.	Design and layout for dredging site and disposal area	5,000.00
5.	Preparation of bidding documents (if required)	2,000.00
6.	Land acquisition for disposal area, 2 acres	5,000.00
7.	Access easement across adjacent property for temporary pipe line (if required)	1,000.00
8.	Disposal area restoration and seeding, 2 acres	7,000.00
Total Project Cost Estimate		\$ 65,000.00

Permit requirements. Although several local, state and federal agencies have jurisdiction over drainage ditches, lakes, and wetlands, the only permit required for

construction of the sedimentation basins is from the Indiana Department of Natural Resources, Division of Water. This "Permit Application for Construction" is required for alterations to the shoreline or bed of a public freshwater lake.

The U.S. Department of the Army, Corps of Engineers will not require a Section 404 permit for this work as long as access roads are not constructed into the lake or surrounding wetlands, and lake or wetland sediments are not moved with a bulldozer or temporarily sidecast onto the lake bottom or jurisdictional wetlands.

The U.S. Environmental Protection Agency may require Section 401 certification or waiver from the Indiana Department of Environmental Management for discharge of return water from the dredge spoil site to any wetland or water body. The concern is for suspended soil particles in the return water from the hydraulic dredging.

The Indiana Department of Environmental Management, however, requires a Section 401 permit only if the project requires a Section 404 permit from the Corps of Engineers. The IDEM does not require a National Pollutant Discharge Elimination System (NPDES) permit as long as the discharge is not contaminated by toxic pollutants which could exceed water quality values. The analysis of lake sediment presented in the draft report (Turnbell, 1988) found that concentrations of volatile and semi-volatile compounds, pesticides, PCBs, heavy metals, cyanide, and phenols were low or below the detection limits of the test procedures.

The LaPorte County Drainage Board will not require a permit if the sediment traps are not constructed in Mill Creek (Sharp Ditch). The Kankakee River Basin Commission does not have any permitting authority, but does consult with local drainage boards and the Indiana Department of Natural Resources on matters affecting the Kankakee River.

Aquatic Macrophyte Management

High densities of aquatic macrophytes can cause a reduction in the recreation potential of a lake by restricting boating, fishing, and swimming. There are, however, many beneficial aspects to a healthy macrophyte community within the lake. Macrophytes can control the abundance of algae within the lake by tying up nutrients and shading the water column, resulting in greater water clarity. A major macrophyte control effort could reduce competition for nitrogen, phosphorus and sunlight, allowing the algae to reproduce to very high densities. These algae "blooms" usually occur in mid-summer and cause murky, malodorous conditions on the lake. Selective and limited control of dense aquatic vegetation will allow fishing and boating use of the lake, but will not cause a large release

of nutrients which contribute to algae growth.

Additionally, macrophyte beds also promote settling of particulate matter and consolidation of bottom sediments. Consolidation of bottom sediments is very important to prevent resuspension during storms and by boat traffic. Macrophyte beds are also very important to the lake fishery by providing cover and spawning sites for game fish and their prey. Aquatic macrophyte control is presented at length later in this report.

Any long-term management plan for Fish Lake should be based on goals which are compatible, realistically attainable, and economically feasible. The goals of this management plan are to:

1. Provide access and recreational use of the lake system.
2. Provide proper weed and algae balance to create a healthy fishery.
3. Use vegetation as a tool to improve water quality.
4. Provide results which are cost-efficient.

In order to meet these goals we recommend a limited treatment program to control macrophyte growth in certain areas to allow unimpeded recreation, while macrophyte beds are maintained in other areas to promote continued algae and nutrient control and provide fish and wildlife benefits.

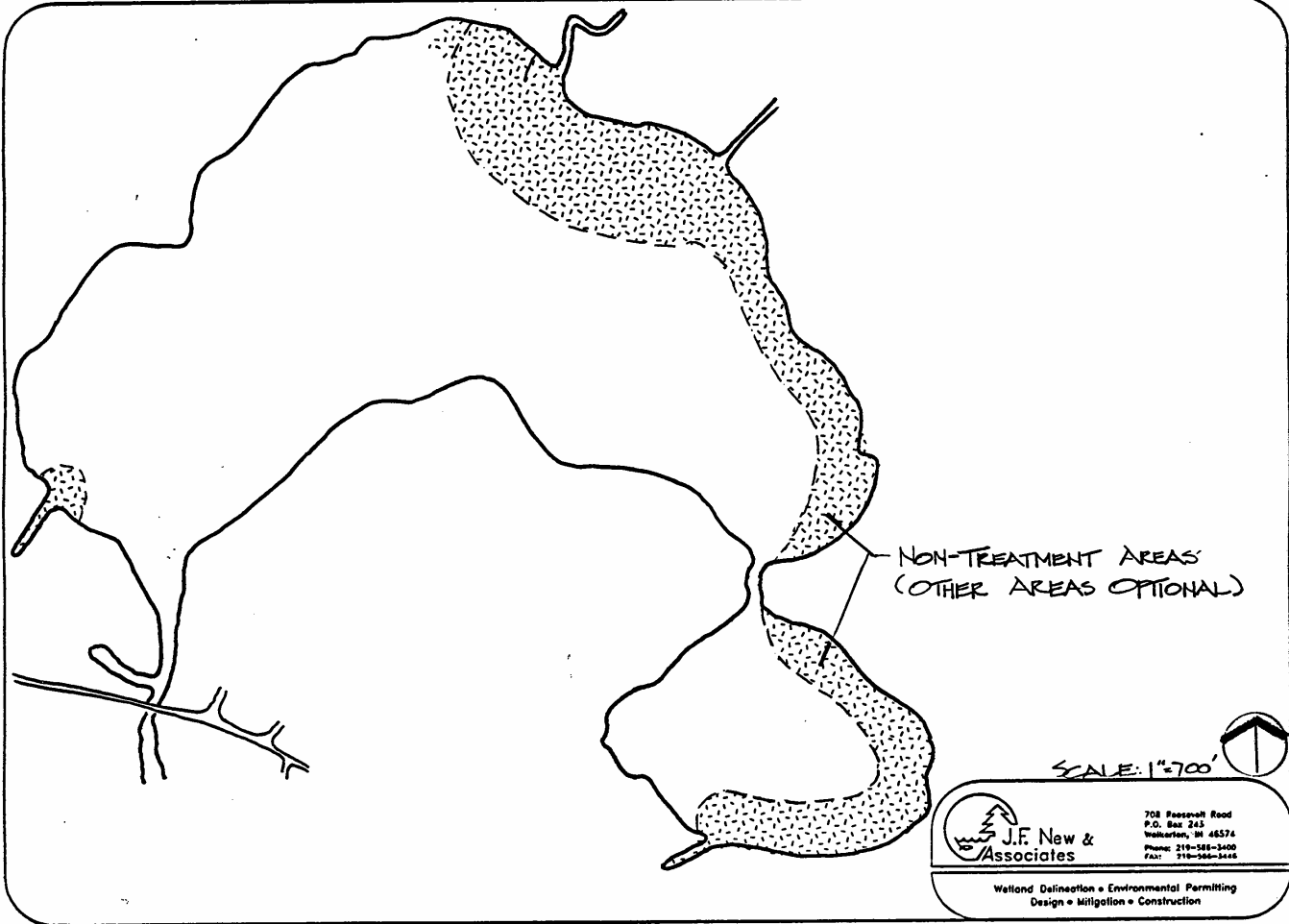
Selective control of dense aquatic vegetation will allow fishing and boating use of the lake, but will not cause a large release of nutrients which contribute to algae growth. Vegetation can be controlled along the shoreline where swimming and boating are impaired. Macrophytes can also be controlled in the channel between Mud and Upper Lake and in the channel between Upper and Lower Lakes, but only to the extent necessary to allow boat traffic. Non-residential shorelines and the Fish Creek and Mill Creek inlets and the weed bed at the north end of Lower Lake should not be treated. Of course, all chemical control of aquatic vegetation should be performed by experienced, licensed applicators. It is important to remember that aquatic vegetation is a valuable component of a healthy lake system.

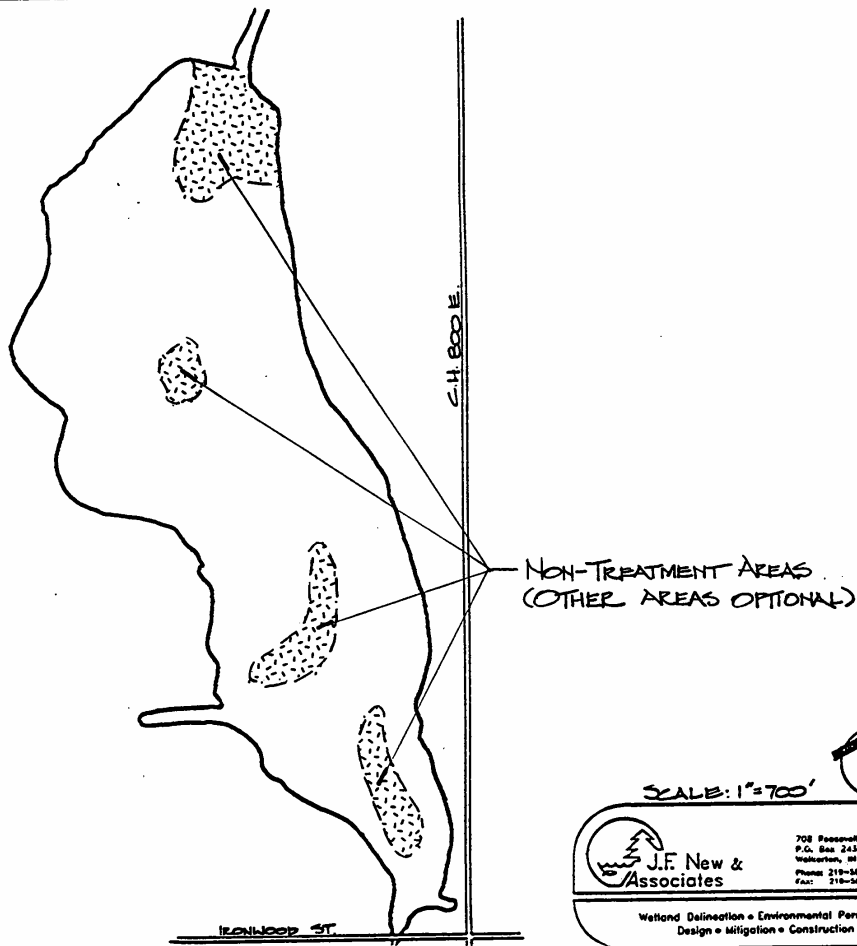
Specific recommendations include:

1. Control *dense* macrophytes as needed within 200 feet of the shoreline in front of homes when swimming or boating is substantially impeded. Lake front property owners should be encouraged to leave macrophyte beds intact when boating or swimming are not at issue.

2. Leave macrophyte beds along non-residential shorelines intact. This will help stabilize the shoreline, tie up nutrients, maintain fisheries, and promote water clarity.
3. Leave intact the extensive macrophyte beds associated with the inlets of Fish and Mill Creeks. These beds are essential in controlling the quality of water entering the lake from these waterways. These areas have developed in response to increased inputs of sediments and nutrients and are extremely important in their control. Removal of plants from these areas would allow suspended sediments and nutrients to flush further out into the lake. Flocculent sediments currently in place would also be released and flushed further out into the lake. Similarly, macrophyte beds or wetland areas that have developed at other inlets to the Fish Lake system should also be left intact.
4. Macrophytes can be controlled in the channel between Upper and Lower Fish Lakes to allow free movement of boats. Similarly, macrophytes in the channel between Mud and Upper Fish Lakes should only be controlled to the extent necessary to allow boat traffic between the two.
5. The macrophyte bed at the north end of Lower Fish Lake should be left intact directly south of the connecting channel to help control the quality of water entering from Upper Fish Lake. Depending on the density of the bed in any particular year it may be necessary to open a boat channel. Disruption of the bed by casual boat traffic in most years, however, should make this unnecessary.

Based on present technology, the use of chemical herbicides and algacides has proven to be the most cost effective tools in short-term vegetation control on many lakes. However, long-term macrophyte management should also include the reduction of sediment and nutrient inputs. By reducing nutrient loading in the water column, the scope of future chemical treatments can also be reduced. Recommended no-treatment zones for Upper and Lower Fish Lakes are shown in Figures 29 and 30.





SCALE: 1"=700'



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Control of individual species is recommended below:

EURASIAN WATER MILFOIL (*Myriophyllum spicatum*)

Eurasian Water Milfoil remains one of the most aggressive aquatic nuisance weed in North America. If left unchecked, its rapid growth tends to replace more desirable native species. Both fragmentation and seed production cause its rapid spread. This species should be targeted for a dramatic reduction.

CURLY LEAF PONDWEED (*Potamogeton crispus*)

This weed reaches the surface early in the spring and often covers a sizeable area. It also matures early and begins to drop naturally from the surface in mid to late June.

FILAMENTOUS ALGAE

This fine hair-like algae responds to increased nutrient loads. It tends to ebb and tide as the mid-summer approaches. Low levels of copper sulfate will control filamentous algae if it develops a nuisance condition.

CHARA (Algae)

This attached algae is considered beneficial in most instances. It grows close to the bottom and ties up nutrients. Chara can be treated in swimming and boating areas.

RICHARDSON'S PONDWEED (*Potamogeton richardsonii*)

This large broadleaf weed does not tend to spread rapidly, but becomes a nuisance in boating areas. Because of its resistance to herbicides, timely applications of approved herbicides are required. Richardson's pondweed is on the IDNR list of endangered species. Control measures such as herbicide applications should be approached cautiously.

EEL GRASS (*Vallisneria americana*)

This weed, often called wild celery, is a summer weed which usually becomes a nuisance in late July. A treatment only in heavily infested areas is recommended due to high chemical cost.

DUCKWEED (*Lemna minor*) and WATER MEAL (*Wolffia* spp.)

Both of these are floating water weeds. They can be controlled with Diquat, but it is rarely practical due to their mobility.

YELLOW and WHITE WATER LILY, SPATTERDOCK, PICKEREL WEED

These emergent species are considered very beneficial, it not in excess. Indiana also limits the volume to be treated, based on the property owner's access to open water.

COONTAIL (*Ceratophyllum* spp.)

This is a minor species in the Fish Lake chain and can be controlled by several herbicides.

SAGO PONDWEED (*Potamogeton pectinatus*)

This minor native species usually requires minimal control.

Aquatic vegetation is dynamic in nature. There are many factors which affect weed growth in any given year. Ice and snow cover, nutrient loads, water clarity and previous weed control are only a few factors which can cause changes in vegetative growth. For that reason, vegetation control should not be based on the previous year's conditions, but rather on an early May inspection, conducted by at least one member of the Fish Lake Property Owners Association, a representative from J.F. New & Associates and the licensed aquatic herbicide applicator. Species priorities and cost per acre, by species, could be established before the inspection so that only the scope of treatment need be established and final contracts can be executed in a timely manner. Finally, all chemical control of aquatic vegetation should be done by a licensed, reputable applicator. This will ensure correct herbicide selection, proper application rates, proper timing of treatment for best results. The herbicide applicator should be made aware of the designated non-treatment areas and should agree to protect those areas from deliberate or inadvertent application of chemicals.

The following are expected 1992 costs per acre of applied herbicides based on species:

AQUATIC SPECIES	HERBICIDE and RATES	COST/ACRE
Eurasian milfoil and other milfoils	2,4-D granules, fast release type, 125 pounds per acre	\$ 275.00
Curly leaf pondweed, coontail, sago pondweed	Diquat/Komeen, 1 to 1.5 gallons per acre	\$ 175.00
Filamentous algae	Copper sulfate	< 10 ac. \$ 85.00 > 10 ac. \$ 55.00
Chara (algae)	Copper sulfate, 15 pounds/acre and Cide-Kick. 0.5 gallons/acre	< 10 ac. \$ 85.00 > 10 ac. \$ 55.00
Richardson's pondweed (see discussion on page 78)	Hydrothol 191 and Aquathol K Plus Nalquatic	\$ 260.00
Eel grass	Hydrothol 191, 150 pounds per acre	\$ 275.00
Floating species: duckweed, water meal	Diquat	\$ 175.00
All emerged species: yellow and white water lily, spatterdock, pickerel weed	Rodeo Plus X77, 2.5 quarter per acre in late summer	\$ 214.00

Using macrophyte density and coverage maps based on the 1991 surveys, treatment costs are projected below:

<u>MUD LAKE</u>	<u>TREATED</u>	<u>COST PER</u>	<u>TOTAL</u>
<u>SPECIES</u>	<u>ACRES</u>	<u>ACRE</u>	<u>COST</u>
Milfoil	7.85	\$ 275.00	\$ 2,185.75
Curly leaf pondweed, coontail	8.5	175.00	1,487.50
Filamentous algae	4.0	47.50	190.00
Chara	2.0	55.00	110.00
Richardson's pondweed	0.5	260.00	130.00
Eel grass	0.5	275.00	137.50
Emergent species	4.5	214.00	963.00
		Sub-Total	\$ 5,076.75

<u>UPPER LAKE</u>	<u>TREATED</u>	<u>COST PER</u>	<u>TOTAL</u>
<u>SPECIES</u>	<u>ACRES</u>	<u>ACRE</u>	<u>COST</u>
Milfoil	39.6	\$ 275.00	\$ 10,890.00
Curly leaf pondweed, sago	21.95	175.00	3,841.25
Filamentous algae	10.0 x 2	47.50	950.00
Chara	5.0	55.00	275.00
Richardson's pondweed	1.5	260.00	390.00
Eel grass	2.5	275.00	685.50
Floating species (Duckweed)	1.0	175.00	175.00
Emergent species	2.5	214.00	535.00
		Sub-Total	\$ 17,743.75

<u>LOWER LAKE</u>	<u>TREATED</u>	<u>COST PER</u>	<u>TOTAL</u>
<u>SPECIES</u>	<u>ACRES</u>	<u>ACRE</u>	<u>COST</u>
Milfoil	14.4	\$ 275.00	\$ 3,960.00
Curly leaf pondweed, sago	10.0	175.00	1,750.00
Chara	6.0	55.00	330.00
Richardson's pondweed	3.1	260.00	806.00
Eel grass	5.2	275.00	1,440.00
Emergent species	0.75	214.00	160.50
		Sub-Total	\$ 8,436.50

TOTAL \$ 31,257.00

The costs described above include required IDNR permit application, chemicals, application, insurance, pre-treatment inspection, post-treatment inspection, and up to 10%

spot retreatment based on cost per acre. These costs are also based on extensive treatments outside the prescribed untreated areas. A number of species not creating a nuisance could easily be eliminated from the treatment, depending on 1992 macrophyte growth in the lake.

Control of Eurasian milfoil should be stressed, with a lesser emphasis on curly leaf pondweed and other less intrusive vegetation. Lake users could expect a long-term reduction of Eurasian milfoil of 60% to 80%. Other species show slower reduction, but in a five-year period, a 50% reduction of problem vegetation is realistic.

Aquatic vegetation management is complex and has many variables. Target species, control areas, and herbicide choices should be discussed with a licensed aquatic herbicide applicator before beginning a treatment program.

Purple Loosestrife

Purple loosestrife (*Lythrum salicaria*), while not specifically addressed in previous reports as a problem in the Fish Lake, is a very aggressive non-native species which has a strong start on the north edge of Upper Fish Lake and has replaced native shoreline vegetation. Property owners should not cultivate this plant or allow it to grow wild on their lake frontage. Unfortunately, large scale chemical or mechanical means of control would probably be ineffective at Fish Lake, according to the IDNR, Division of Nature Preserves. The United States Department of Agriculture has evaluated several very host-specific biological control insects and has approved propagation and release programs. The IDNR, Division of Entomology, currently has plans to obtain and propagate the biological control insects but is awaiting funding. If a purple loosestrife control program becomes available in the future, the Lake Association should participate to the fullest extent possible.

Other Lake and Watershed Management Considerations

All wetlands in the watershed, whether or not directly adjacent to the lake, are important in maintaining water quality. Fish Lake residents can protect the quality of the lake by promptly reporting all wetland filling and peat mining activities in the watershed, especially if water is discharged directly into streams or ditches. Agencies which should be notified of these activities include the U.S. Army Corps of Engineers, the U.S. Environmental Protection Agency, the Indiana Department of Environmental Management, the Indiana Department of Natural Resources and the LaPorte County Drainage Board.

It is strongly recommend that any future peat mining operation which discharges water into ditches or streams be required to construct an adequate sediment trap and to filter the water-borne particles which would otherwise flow into the Fish Lake system. All excavation or construction sites which could result in erosion of material into the lake should be protected with silt screening, straw bales or erosion control blankets.

In keeping with wise land use practices, livestock feedlots and holding pens should not be constructed near streams or ditches, and animal waste should not be spread near ditches or other drainage ways.

As sediment and nutrient loading from the watershed is decreased, the nutrient input from septic systems becomes a more important factor. The LaPorte County Health Department takes water samples from Upper and Lower Fish Lake each week during the summer. These samples are examined for *E. coli* bacteria which indicate the presence of waste from warm blooded animals. This bacteria does not specifically indicate the presence of septic system effluent but is a good indicator. The health department may also test at specific locations along the shoreline if septic problems are suspected. Dye testing can be used to confirm the source of the effluent. Fish Lake residents may anonymously report suspected septic problems and should do so promptly. Nutrient input is not the only issue here. High bacterial counts contribute to unhealthy swimming conditions and an unhealthy public image of the lake.

The Fish Lake Property Owners Association should initiate a water quality monitoring program. Until the sediment traps are constructed, samples should be taken at the Fish Creek and Mill Creek inlets. Once the sediment traps are constructed, samples should be taken immediately above and below each one. Other sample locations could include the center of each lake for a general indication of water quality or at specific points nearer the shoreline to monitor environmental or cultural influences.

A monthly sampling program would include one sample taken from each site in April, June, August and October and after major storm events. Water samples should be analyzed for total suspended solids, total Kjeldahl nitrogen and total phosphorus. Environmental laboratories in LaPorte or South Bend can analyze water samples.

Water turbidity should be monitored by Secchi disk readings. Readings should be taken weekly if possible at standardized locations within the lake. The Association can participate in the Volunteer Lake Monitoring Program administered by the Indiana University School of Public and Environmental Affairs under contract from the Indiana Department of Environmental Management. This program monitors Secchi disk readings and evaluates water turbidity information from participating lakes. The Association is

encouraged to participate in this study.

The Association is also strongly encouraged to work with the "T by 2000" program staff to develop a program to monitor the effectiveness of the sediment/nutrient reduction basins, if constructed, and the general health of lake. Such a program would be invaluable in determining when the basins might have to be cleaned and whether adjustments are needed. The Indiana University School of Public and Environmental Affairs is currently funded by Section 319 of the Clean Water Act to support monitoring programs for Indiana's lakes.

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APPENDIX A

LAND TREATMENT ASSISTANCE

LAND TREATMENT ASSISTANCE

IDNR Division of Soils, "T by 2000" Program is "aimed at significantly reducing soil erosion and resulting sedimentation throughout Indiana within a definite time period." The two goals of this program are to "reduce erosion on each acre of land to its tolerable limit or T (the maximum level at which soil loss can occur without impairing crop productivity)" and to "control all off-site sedimentation using the best practical technology" by the year 2000. The five components of this program include soil conservation education assistance, agricultural erosion control technical assistance, cropland erosion control cost-share program, non-agricultural erosion control technical assistance and a lake enhancement program. The Lake Enhancement Program provides technical and financial help to control sediment and associated nutrient problems in public-access lakes.

USDA "Conservation Reserve Program" Cropland which is highly erodible or meets other conditions is eligible for the long-term Conservation Reserve Program (CRP). Land owners bid for rental of highly erodible cropland to the USDA for a ten-year period. Bids are accepted for fields providing the highest level of environmental benefits per CRP dollar spent. Factors considered include surface and ground water quality, maintenance of soil productivity and the extent of tree planting. CRP acreage on which hardwood trees, wildlife corridors, windbreaks or shelterbelts are established may qualify for extended payments.

The USDA also provides multi-year cost-share assistance for establishing perennial vegetative cover on Acreage Conservation Reserve (ACR) or "set-aside" cropland. The cost-share rate is 25 percent of the eligible cost and the farm operator must agree to maintain the cover for at least three years after the calendar year of establishment.

The *Tri-County Water Quality Project* was begun in 1991 to "protect and improve the quality of surface and ground water resources within the project area" in the Upper Kankakee River Basin, including the Fish Lake watershed. This voluntary program offers technical assistance through the Soil Conservation Service, educational assistance from the Purdue Cooperative Extension Service and cost-share assistance through the Agricultural Stabilization and Conservation Service. The LaPorte County Soil and Water Conservation District has mailed program information to eligible landowners. The program has ample funding and now provides 75% cost share for approved practices. Approved practices for LaPorte County include:

SL-1 Permanent Vegetative Cover Establishment establishes grass/legume mixture on land needing wind or water erosion protection. Seventy-five percent cost sharing is authorized for seedbed preparation and seeding, minerals and eligible seed.

SL-2 Permanent Vegetative Cover Improvement provides 75% cost sharing for land in permanent vegetative cover which needs improvement or protection to control erosion.

SL-4 Terrace Systems to control erosion and reduce pollution from cropland. Seventy-five percent cost sharing is available for terraces and necessary leveling and filling to create an effective system.

SL-6 Grazing Land Protection is for installations which provide water at locations that will achieve erosion control. Seventy-five percent cost-sharing is authorized for the development of springs, seeps, wells, dams, ponds and fencing as needed.

SL-7 Field Windbreak Restoration or Establishment can be applied to farmland which needs protection from serious wind erosion. Cost sharing of 75% is authorized for planting trees or shrubs as needed and fencing to protect from grazing.

SL-8 Cropland Protective Cover is for cropland needing erosion protection between crops. The 75% cost sharing is limited to the seed and seeding operations.

SL-9 Farmstead or Feedlot Windbreak can be applied to farmsteads or feedlots that need protection from serious wind erosion. Seventy-five percent cost sharing is authorized for planting trees and shrubs, and for fencing.

SL-11 Permanent Vegetative Cover on All Critical Areas is a practice to be applied to critical areas which are susceptible to erosion or runoff. These areas can include gullies, embankments, field borders and other problem areas. Cost sharing can be applied to stabilizing measures and the establishment of grasses, trees or shrubs. The cost-sharing rate is 75%.

SL-13 Contour Farming is for non-terraced cropland which is subject to wind or water erosion. The 75% cost-sharing is limited to establishing a contour farming system.

SL-15 No-Till Systems is designed to reduce erosion, sediment and pollution from land in crop production. Cost-sharing is authorized for planter rental and burn-down chemicals which are not used in conventional production of the crop.

WC-1 Water Impoundment Reservoirs is applicable to farmland where the construction or sealing of water impoundment structures is needed for erosion control and water quality. Structures which provide erosion control benefits are eligible for 45% cost-share funding.

WP-1 Sediment Retention, Erosion or Water Control Structures is available for specific problem areas where runoff carries significant amounts of sediment or where runoff is a substantial pollution hazard. Seventy-five percent cost sharing is authorized for sediment detention or retention structures, desilting reservoirs, and drop spillways.

WP-2 Stream Protection is designed for problem areas on small streams or lakes where livestock damage or sediment runoff from farmland creates a pollution hazard. Cost sharing of 75% is authorized for filter strips, livestock crossings and fencing to protect banks from damage by livestock.

WP-4 Agricultural Waste Facility is applicable where agricultural (i.e. livestock) is a significant pollution hazard. Seventy-five percent cost-sharing is authorized for many types of waste storage facilities.

FR-1 Forest Tree Plantations can be planted on farmland suitable for growing tree or shrub species providing multipurpose forest benefits. Cost sharing of 75% is authorized for tree and shrub planting stock, planting costs and herbicides as needed.

FR-2 Forest Tree Stand Improvement is authorized for thinning and pruning trees in an existing forest. The cost-sharing rate is 75%.

FR-3 Site Preparation for Natural Regeneration can be applied to existing forests where brush, dense litter or grapevines are hindering seedling growth. Preparation for natural reseeding is cost-shared at 75%.

WL-1 Permanent Wildlife Habitat is applicable to farmland which needs protection from erosion and which is also suitable for establishment of permanent wildlife habitat. Seventy-five percent cost-sharing is authorized for establishing or improving a stand of trees, shrubs, grasses or legumes which provide permanent wildlife cover, habitat or food.

WL-2 Shallow Water Areas for Wildlife provides 75% cost sharing for authorized activities such as earthmoving to construct dams, levees, and shallow water areas for wildlife.

SP-53 Integrated Crop Management can be applied to cropland where reduced use of pesticides and nutrients will reduce water, land or air pollution while keeping the land in crop production.

The LaPorte County Soil and Water Conservation District provides technical assistance and cost-sharing on land used for agricultural production; technical assistance is available to all landowners.

Indiana Department of Natural Resources "Classified Wildlife Habitat Act" provides property tax savings for areas 15 acres or larger reserved for wildlife habitat. All land, not just highly erodible land, is eligible for this program. In exchange for preserving the parcel for wildlife habitat, the acreage enrolled in the CWHHA program is assessed at \$1.00 per acre for property tax purposes, although drainage assessments will not be reduced.

Land enrolled in the Classified Wildlife Habitat program may not be used for farming or grazing, nor may it include homes or other structures. Other than these restrictions, the property owner maintains all control over land use for hunting, hiking, firewood cutting and other activities. The owner is not required to allow public access to the land. The property owner may plant food plots or wildlife habitat on the acreage, but this is not required.

The land may be sold, given or inherited with no effect on the CWHHA enrollment. The owner may withdraw the parcel from Classified Wildlife Habitat, although he may be required to repay property taxes and interest for the years in the program, up to a maximum of ten years enrollment.

Landowners may enroll in the Conservation Reserve Program and the Classified Wildlife Habitat Program at the same time, protecting highly erodible lands and providing wildlife habitat while receiving annual rental payments and reduced property taxes. Interested property owners should contact the IDNR District Wildlife Biologist for more information.

Indiana Department of Natural Resources, "Classified Forest" Program is similar to the Classified Wildlife program and also offers significant property tax savings for areas reserved for forestry purposes such as tree plantations. Land enrolled in the Classified Forest program is assessed at \$4.00 per acre for property tax purposes. More information is available from the IDNR District Forester.

U.S. Fish & Wildlife Service's Wetland Restoration Program may be of interest to land owners who wish to restore drained areas to wetlands. The program was begun in 1988 to construct simple water impoundment dikes and water control structures at no cost to the land owner. These restored wetlands are not sterile "farm ponds", but are diverse and highly productive wildlife habitats, which also provide storage and purification of storm water runoff.

APPENDIX B

LABORATORY REPORTS

SUMMARY DATA FOR BOD ANALYSIS

FISH LAKE: 4/15/91

<u>Sample #</u>	<u>DAY 1</u> mg/L DO	<u>DAY 5</u> mg/L DO	<u>BOD</u> mg/L DO
1	9.3	7.9	1.4
2	9.5	5.8	3.7
3	6.8	5.1	1.7
4	7.0	5.2	1.8
5	7.8	6.2	1.6
6	6.0	4.0	2.0
7	9.2	4.3	4.9
8	11.9	9.4	2.5
9	10.2	8.9	1.3
10	6.5	4.3	2.2
11	3.8	1.8	2.0

SUMMARY DATA FOR TOTAL SUSPENDED SOLIDS

<u>Sample #</u>	<u>TSS</u> mg/L
1	5
2	5
3	6
4	8
5	5
6	15
7	6
8	8
9	7
10	4
11	9

SUMMARY DATA FOR TOTAL KJELDAHL NITROGEN

FISH LAKE: 4/15/91

<u>Sample #</u>	<u>TKN mg/L</u>
1	6.7
2	2.1
3	2.1
4	2.5
5	1.3
6	2.5
7	2.1
8	0.8
9	1.7
10	2.1
11	2.1

SUMMARY DATA FOR TOTAL PHOSPHORUS

<u>Sample #</u>	<u>Total Phosphorus 3- mg/L PO₄</u>
1	0.15
2	0.01
3	0.00
4	0.25
5	0.11
6	0.05
7	0.00
8	0.00
9	0.00
10	0.00
11	0.02

ENVIRONMENTAL TESTING OF LAPORTE COUNTY, INC.
1410 C STREET, LAPORTE, IN 46350
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SUMMARY DATA FOR TOTAL SUSPENDED SOLIDS ANALYSES

Sample # TSS
 mg/L

FISH LAKE: 6/18/91

1 2.0
2 4.5
3 9.0
4 2.5
5 0.5
6 2.0
7 10.5
8 3.0
9 2.0
10 0.0

SUMMARY DATA FOR BOD ANALYSES

Sample # DAY 1 DAY 5 BOD
 mg/L mg/L mg/L

1	5.6	7.7	--- *
2	1.6	0.2	1.4
3	0.5	0.0	0.5
4	6.9	5.5	1.4
5	3.9	4.8	---
6	3.3	4.1	---
7	4.0	0.0	4.0
8	2.7	8.5	---
9	4.1	4.7	---
10	4.5	8.1	---

* Day 1 value is lower than day 5 value, no BOD could be determined.

ENVIRONMENTAL TESTING OF LAPORTE COUNTY,

Quality Control Data Report

ETLC project # 91-6-1Client J. F. New + Associates

FISH LAKE: 6/18/91

Date	#	Analyst	Parameter	Method Standard			Precision-duplicate data					
				True Value	Obs Value	% Recov	A	B	%RSD	Mean	Units	Matrix
6/18	1	gc	Day 1 DO/BOD	10.0	10.36	103.6%	5.2	6		5.6	mg/L	w
"	2	"	"				1.5	1.6		1.6	"	"
"	3	"	"				0.4	0.5		0.5	"	"
"	4	"	"				9.0	4.7		6.9	"	"
"	5	"	"				3.5	4.3		3.9	"	"
"	6	"	"				3.3	3.3		3.3	"	"
"	7	"	"				4.1	3.9		4.0	"	"
"	8	"	"				2.1	3.3		2.7	"	"
"	9	"	"				3.9	4.2		4.1	"	"
"	10	"	"				3.5	5.4		4.5	"	"

% RSD = $100 * |A-B| / \text{Mean}$ % Recovery = $100 * (\text{Obs} / \text{True})$

Matrix: w = water, s = solid, o = other

Quality Control Data Report

ETLC project # 91-6-1Client J.F. New + Associates

FISH LAKE: 6/18/91

Date	#	Analyst	Parameter	Method Standard			Precision-duplicate data						Units	Matrix
				True Value	Obs Value	% Recov	A	B	%RSD	Mean				
6/19	1	QC	Total Phos	1.0	0.98	98%	0.06	0.00		0.03			mg/L	w
"	2	"	"				0.18	0.00		0.09				w
"	3	"	"				1.16	1.24		1.2				"
"	4	"	"				0.01	0.35		0.18				"
"	5	"	"				0.01	0.00		0.01				"
"	6	"	"				0.01	0.01		0.01				"
"	7	"	"				0.3	0.22		0.26				"
"	8	"	"				0.0	0.04		0.02				"
"	9	"	"				0.1	0.0	0.0	0.05				"
"	10	"	"				0.1	0.19		0.15				"

% RSD = $100 * |A-B| / \text{Mean}$ % Recovery = $100 * (\text{Obs} / \text{True})$

Matrix: w = water, s = solid, o = other

ENVIRONMENTAL TESTING OF LAPORTE COUNTY,

Quality Control Data Report

ETLC project # 91-6-1Client J. F. New + Associates

FISH LAKE: 6/18/91

FISH LAKE: 6/18/91

Date	#	Analyst	Parameter	Method Standard			Precision-duplicate data					
				True Value	Obs Value	% Recov	A	B	%RSD	Mean	Units	Matrix
6/20	1	JC	TKN	33	36	109%	2.9	4.6		3.8	mg/L	w
"	2	"	"				1.3	1.3		1.3	"	"
6/21	3	"	"				0.8	0.8		0.8	"	"
"	4	"	"				0.4	1.3		0.9	"	"
"	5	"	"				0.4	1.3		0.9	"	"
6/22	6	"	"				0.8	1.3		1.1	"	"
6/21	7	"	"				2.9	2.9		2.9	"	"
"	8	"	"				0.8	1.3		1.1	"	"
"	9	"	"				1.7	0.8		1.3	"	"
"	10	"	"				0.8	1.3		1.1	"	"

% RSD = $100 * |A-B| / \text{Mean}$ % Recovery = $100 * (\text{Obs} / \text{True})$

Matrix: w = water, s = solid, o = other

ENVIRONMENTAL TESTING OF LAPORTE COUNTY,

Quality Control Data Report

ETLC project # 91-6-1Client J.F. New + Associates

FISH LAKE: 6/18/91

				Method Standard			Precision-duplicate data					
Date	#	Analyst	Parameter	True Value	Obs Value	% Recov	A	B	%RSD	Mean	Units	Matrix
6/22	1	JK	TSS				1	3		2	mg/L	w
"	2	"	"				5	4		4.5	"	"
"	3	"	"				10	8		9	"	"
"	4	"	"				3	2		2.5	"	"
"	5	"	"				0	1		0.5	"	"
"	6	"	"				3	1		2	"	"
"	7	"	"				11	10		10.5	"	"
"	8	"	"				4	2		3	"	"
"	9	"	"				3	1		2	"	"
"	10	"	"				0	0		0	"	"

% RSD = $100 * |A-B| / \text{Mean}$ % Recovery = $100 * (\text{Obs}/\text{True})$

Matrix: w = water, s = solid, o = other

ENVIRONMENTAL TESTING OF LAPORTE COUNTY,

Quality Control Data Report

ETLC project # 91-6-1Client J.F. New + Associates

FISH LAKE: 6/18/91

Date	#	Analyst	Parameter	Method Standard			Precision-duplicate data					Units	Matrix
				True Value	Obs Value	% Recov	A	B	%RSD	Mean			
6/23	1	JL	Day 5 00/000	10.0	10.16	101.6%	7.4	8.0		7.7		w	
"	2	"					0.2	0.24		0.22		"	
"	3	"					0.0	0.0		0.0		"	
"	4	"					5.2	5.8		5.5		"	
"	5	"					4.4	5.1		4.8		"	
"	6	"					3.5	4.6		4.1		"	
"	7	"					0.0	0.0		0.0		"	
"	8	"					8.4	8.6		8.5		"	
"	9	"					4.7	4.6		4.65		"	
"	10	"					8.2	8.0		8.1		"	

% RSD = $100 * |A-B| / \text{Mean}$ % Recovery = $100 * (\text{Obs} / \text{True})$

Matrix: w = water, s = solid, o = other

ENVIRONMENTAL TESTING OF LAPORTE COUNTY, INC.
1410 C STREET, LAPORTE, IN 46350
(219) 324-9939

SUMMARY DATA FOR TOTAL KJELDAHL NITROGEN ANALYSES

Sample #	TKN mg/L
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1	3.8
2	1.3
3	0.8
4	0.9
5	0.9
6	1.1
7	2.9
8	1.1
9	1.3
10	1.1

FISH LAKE: 6/18/91

SUMMARY DATA FOR TOTAL PHOSPHORUS ANALYSES

Sample #	Total phosphorus mg/L PO ₄ ³⁻
----------	--

1	0.03
2	0.09
3	1.20
4	0.18
5	0.01
6	0.01
7	0.26
8	0.02
9	0.05
10	0.15

APPENDIX C
SEDIMENT DEPOSITS

UPPER FISH LAKE SEDIMENT DEPOSITS

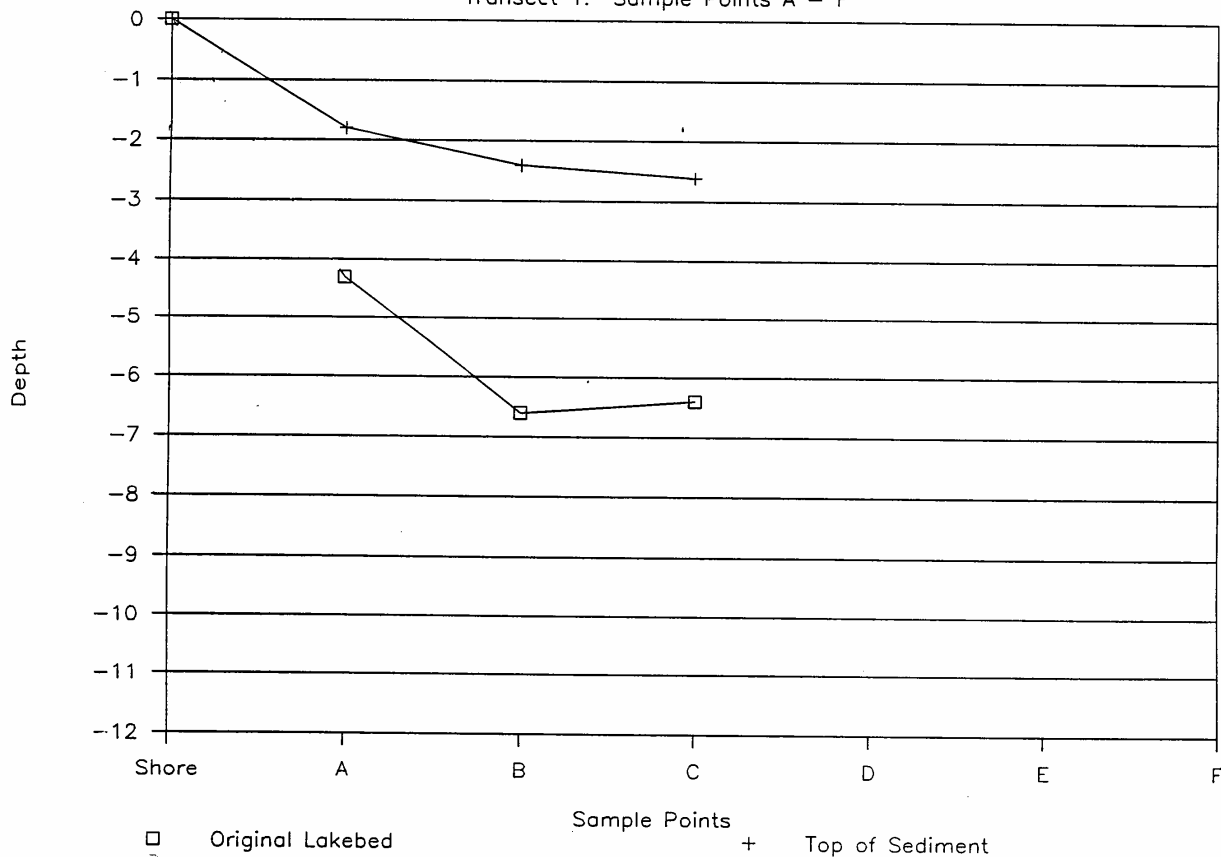
The results of core sampling at the north end of Upper Fish Lake are shown on the following graphs. Core sampling in this area documents the extent, volume and composition of sediment deposits from Fish Creek and Mill Creek. The sediment core sample locations are shown in Figure 15 (page 35) and the sediment data is presented in Table 3 (pages 37-38).

The following two-dimensional graphs show the depth of the "original" lakebed and the top of the uncompressed sediment in the nine transects. These transects depict a cross section from the lakeshore at the left side of the graph to open water on the right.

To give a more complete picture of the extent of sediment deposition, the same data is presented in three-dimensional graphs (Figures 17 and 18, pages 41 and 42).

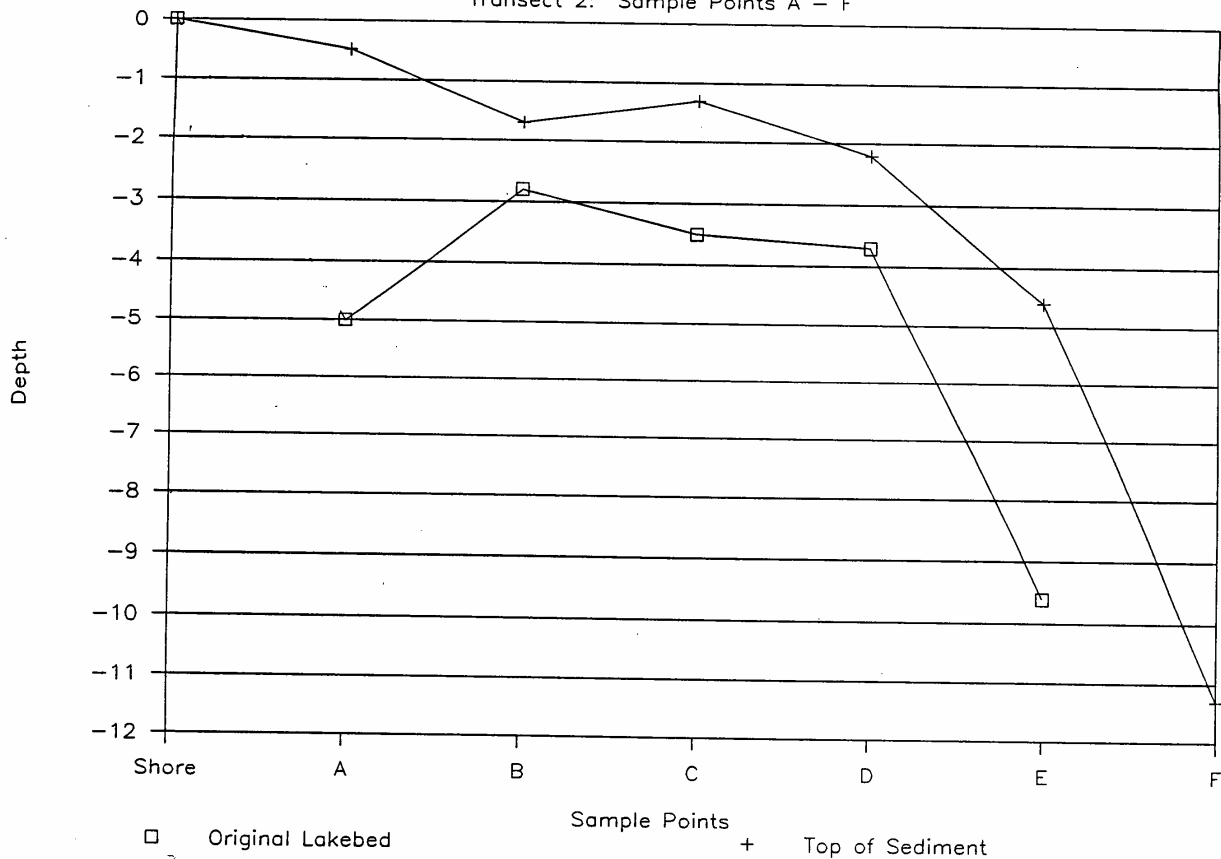
Fish Lake Sediment Survey

Transect 1: Sample Points A – F



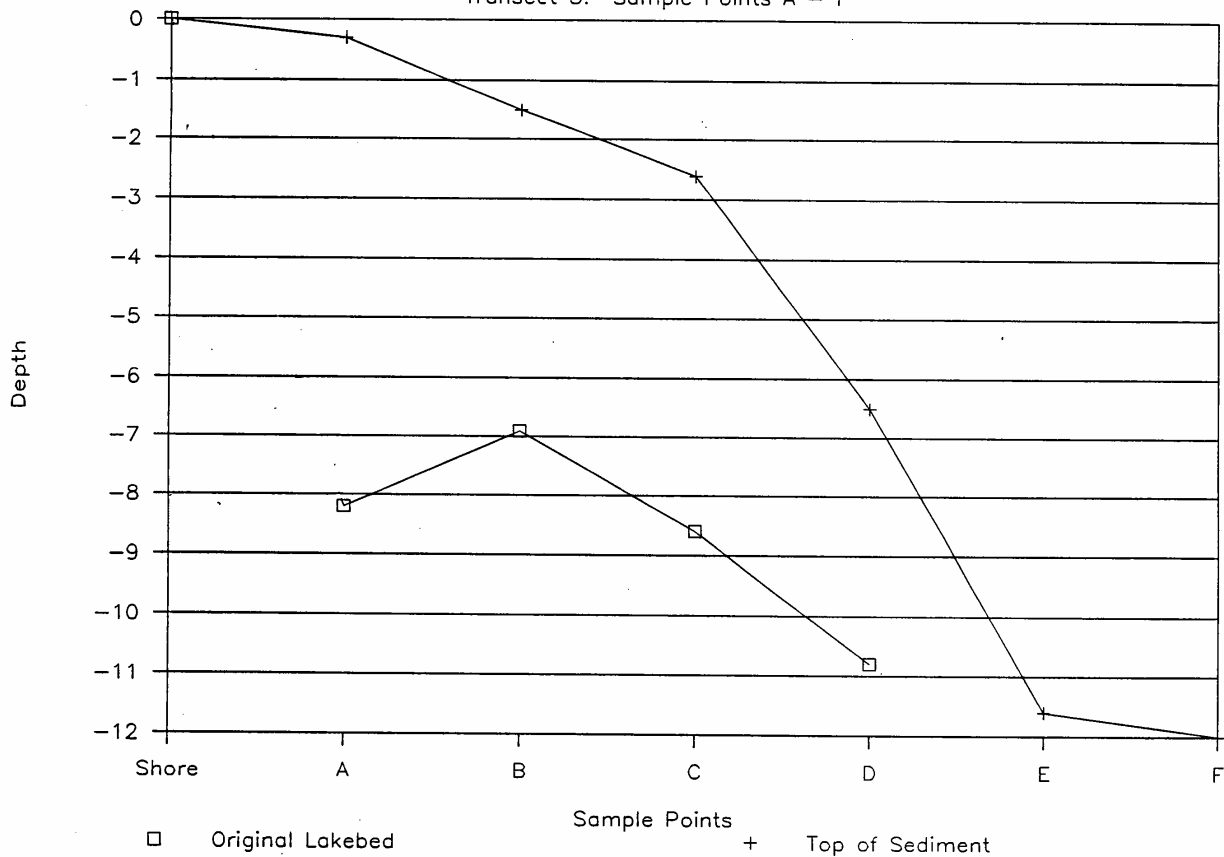
Fish Lake Sediment Survey

Transect 2: Sample Points A – F



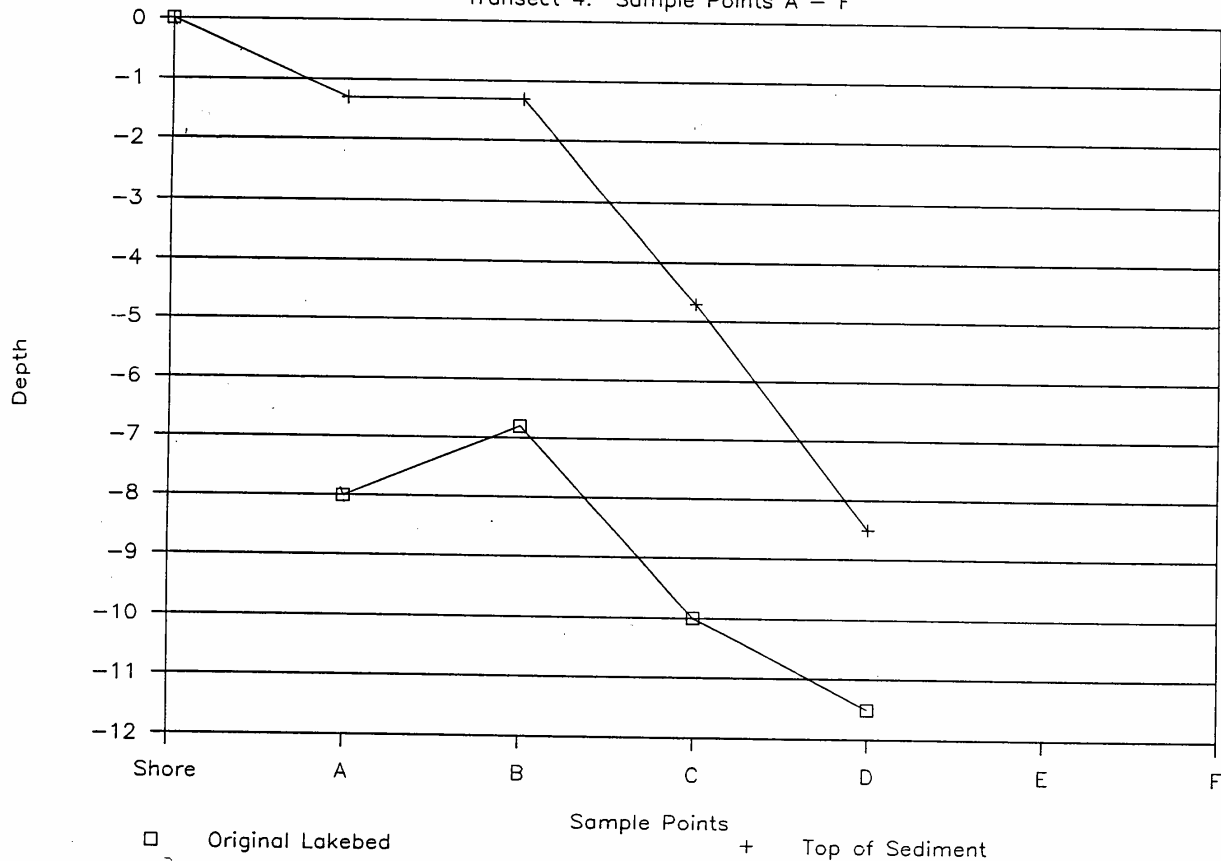
Fish Lake Sediment Survey

Transect 3: Sample Points A – F



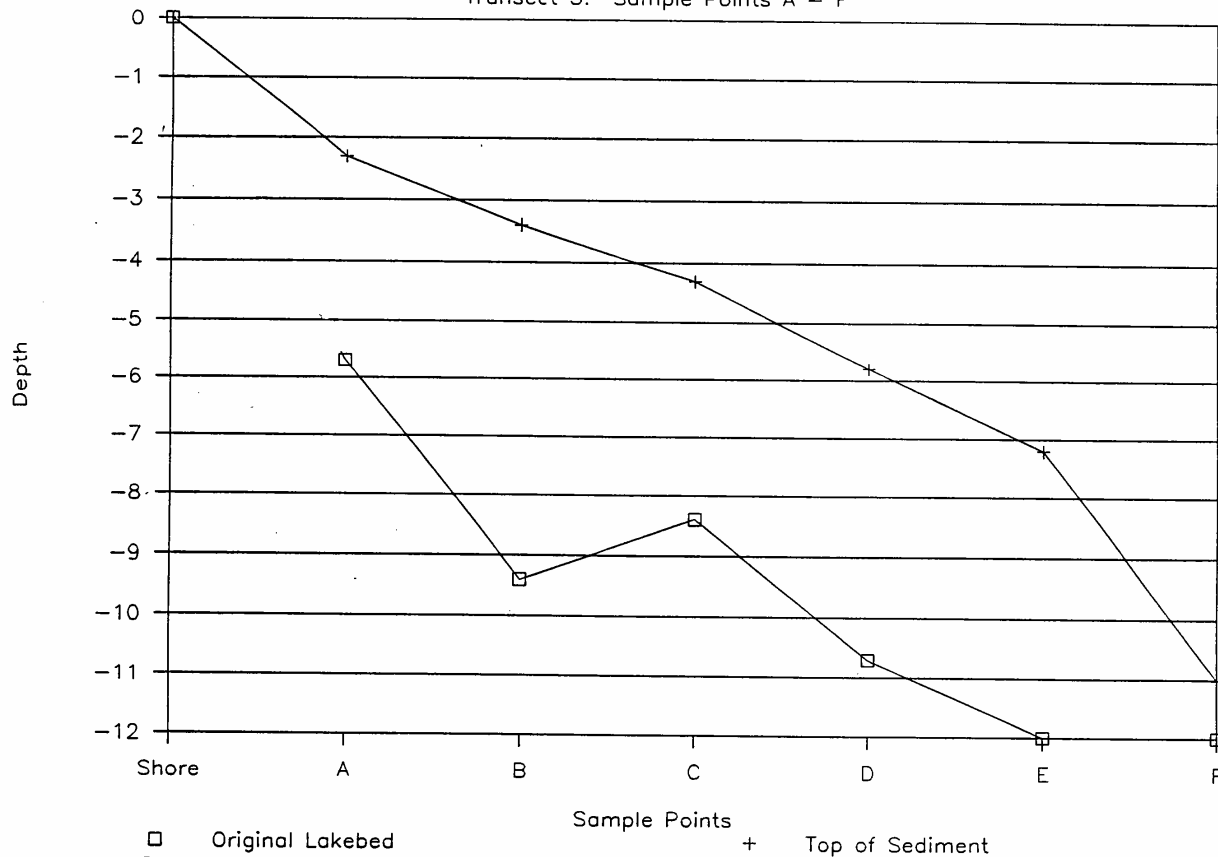
Fish Lake, Sediment Survey

Transect 4: Sample Points A - F



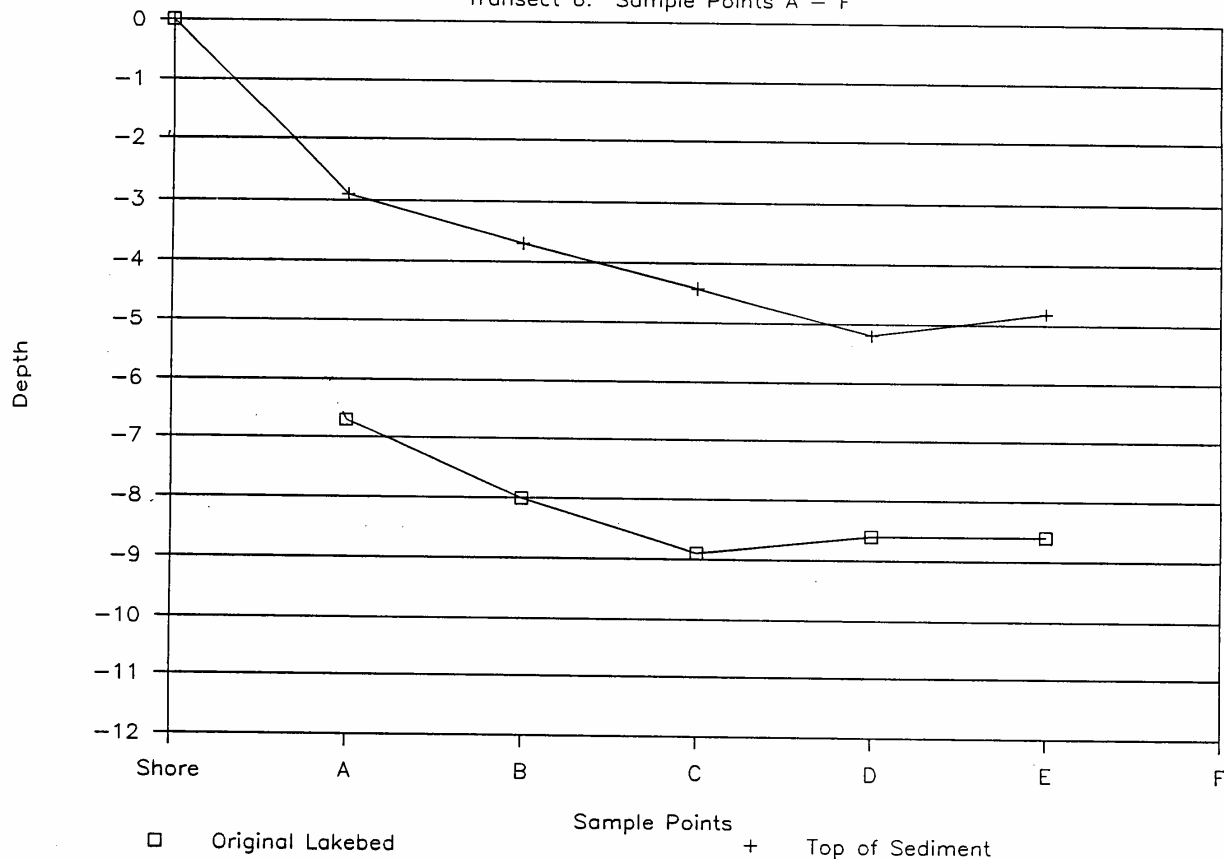
Fish Lake Sediment Survey

Transect 5: Sample Points A – F



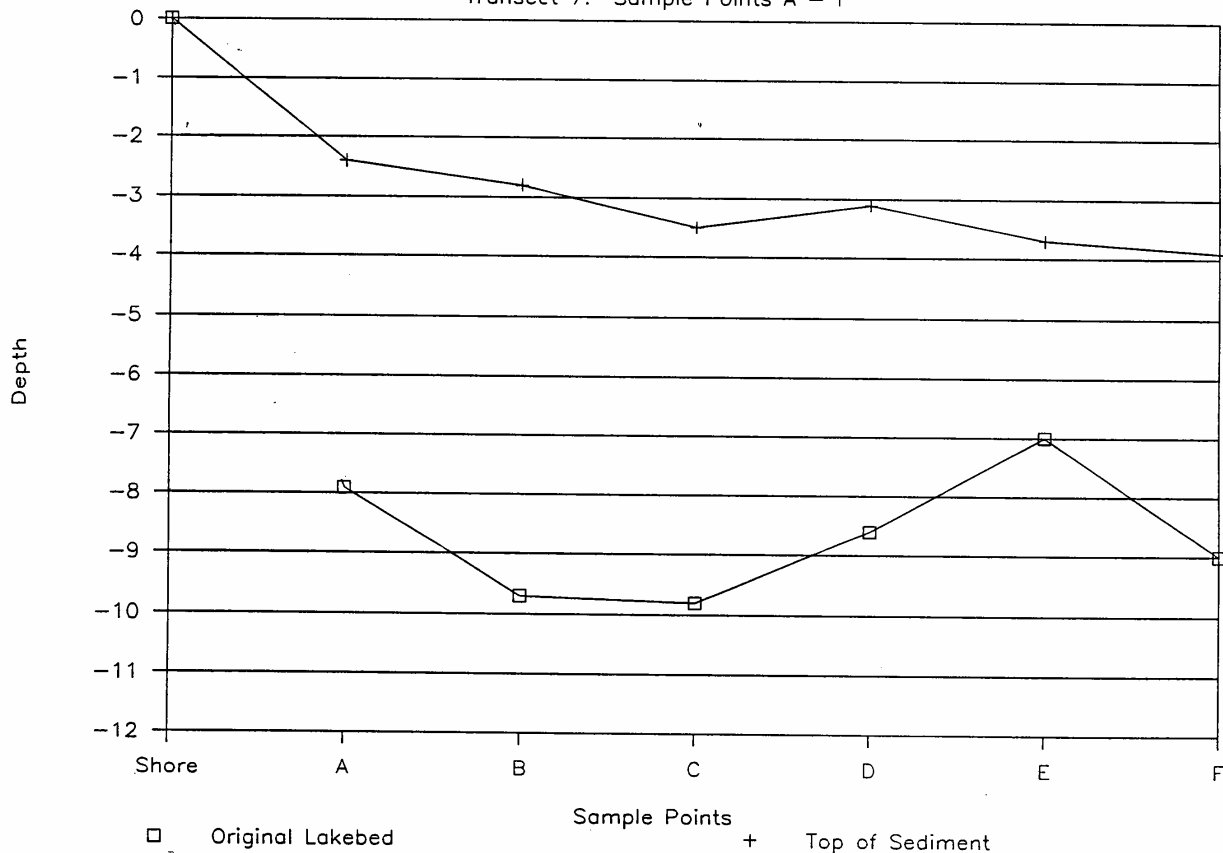
Fish Lake Sediment Survey

Transect 6: Sample Points A – F



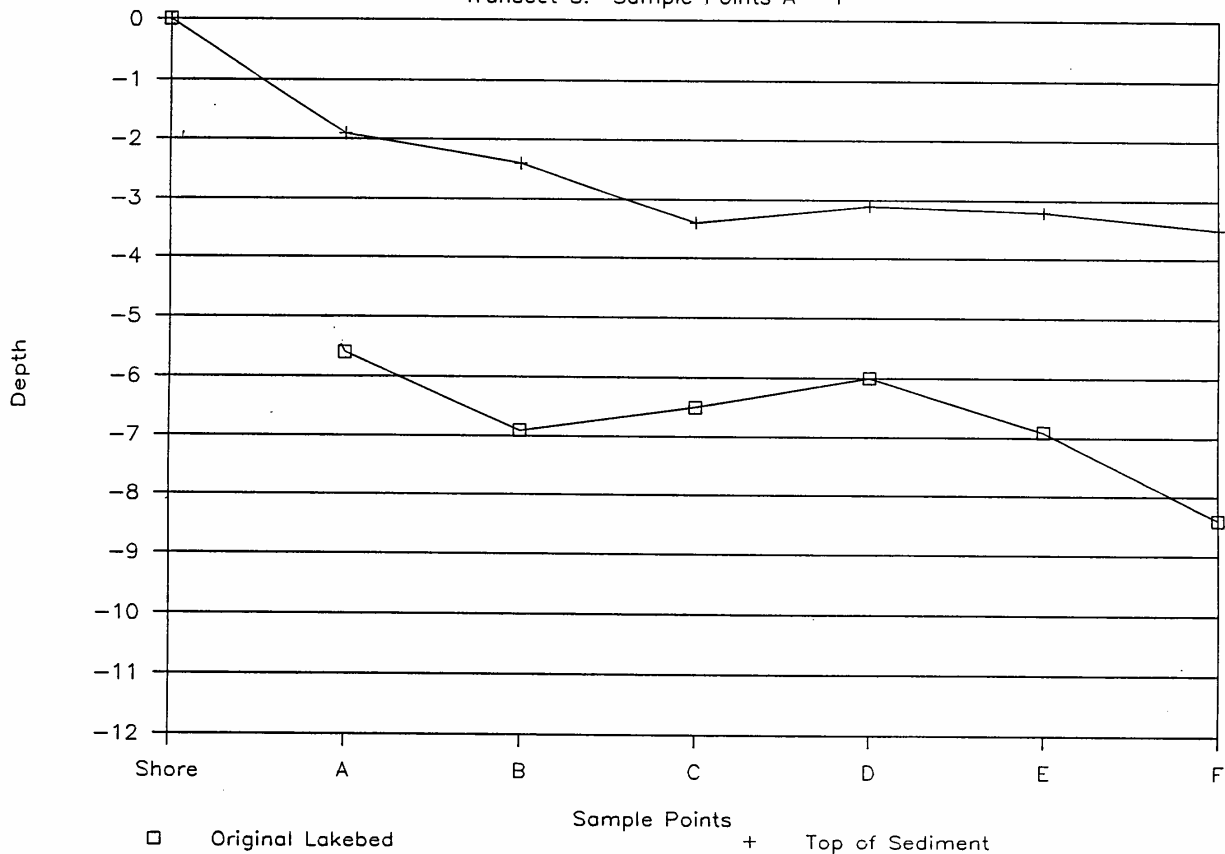
Fish Lake Sediment Survey

Transect 7: Sample Points A – F



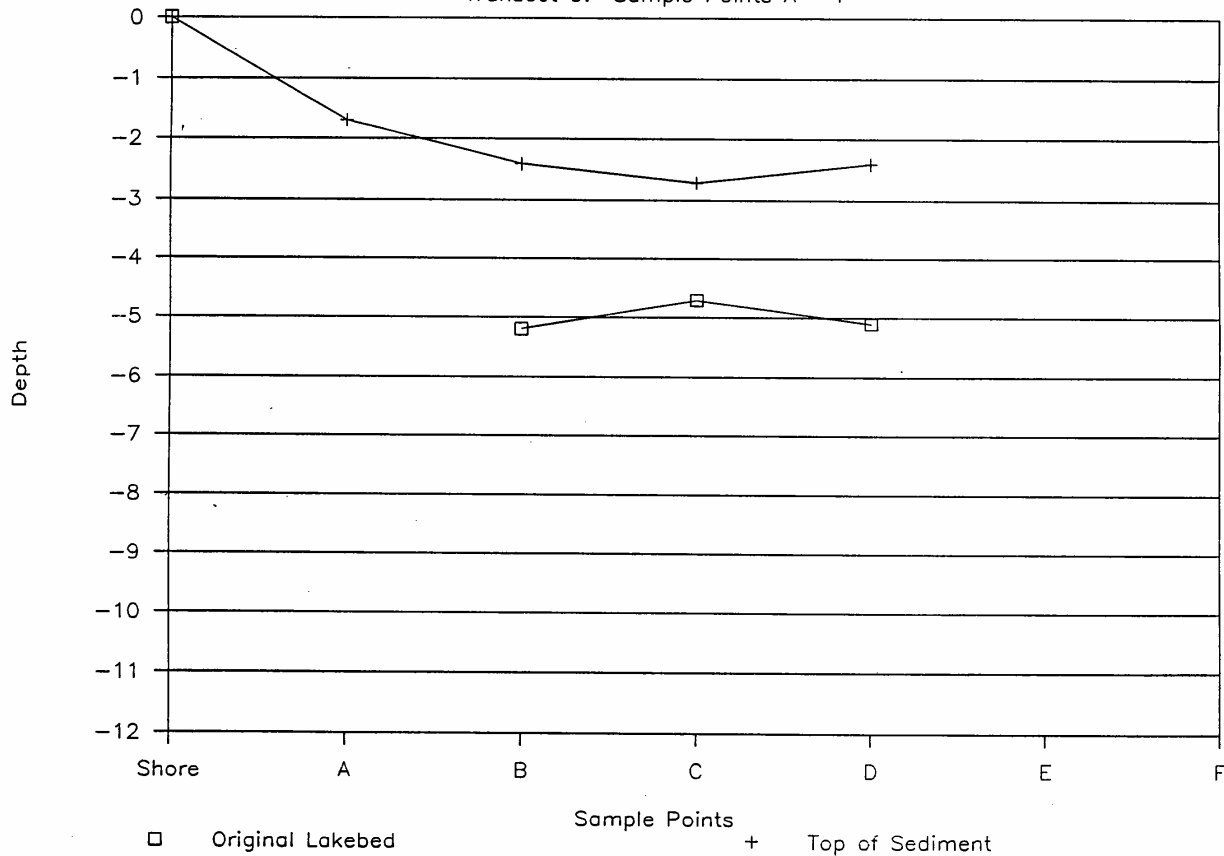
Fish Lake Sediment Survey

Transect 8: Sample Points A – F



Fish Lake Sediment Survey

Transect 9: Sample Points A – F



APPENDIX D

LOCAL, STATE AND FEDERAL AGENCIES

U.S. Army, Corps of Engineers
Regulatory Functions Branch
P.O. Box 1027
Detroit, Michigan 48231-1027
(313) 226-2222

U.S. Environmental Protection Agency
Water Quality Section 5WQA-TUB8
230 South Dearborn Street
Chicago, Illinois 60604
(312) 886-6678

U.S. Fish and Wildlife Service
Bloomington Field Office
718 North Walnut Street
Bloomington, Indiana 47401
(812) 334-4261

Indiana Department of Environmental Management
Office of Water Management
5500 West Bradbury
Indianapolis, Indiana 46241
(317) 243-5028

Indiana Department of Natural Resources
Division of Water
402 West Washington Street, Room 264
Indianapolis, Indiana 46204
(317) 232-4160

Indiana Department of Natural Resources
Division of Nature Preserves
402 West Washington Street
Indianapolis, Indiana 46204
(317) 232-4052

Indiana Department of Natural Resources
Division of Soil Conservation
Lake Enhancement Program
402 West Washington Street, W-Room 265
Indianapolis, Indiana 46204
(317) 233-3870

Indiana Department of Natural Resources
Division of Fish and Wildlife
District Wildlife Biologist
5344 South Hupp Road
LaPorte, Indiana 46350
(219) 393-5459

Indiana Department of Natural Resources
Division of Forestry
District Forester
R.R. #3
Knox, Indiana 46534
(219) 772-5848

LaPorte County Soil and Water Conservation District
1714 "A" Street
LaPorte, Indiana 46350
(219) 362-6633

Agricultural Stabilization and Conservation Service
1712 "A" Street
LaPorte, Indiana 46350
(219) 362-2820

LaPorte County Health Department
Courthouse Annex, 5th Floor
LaPorte, Indiana 46350
(219) 326-6808

Indiana University
School of Public and Environmental Affairs
Volunteer Lake Monitoring Program
Bloomington, Indiana 47405
(812) 855-4556